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AUGUST 1952

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AERONAUTICAL ENGINEERING REVIEW

Vol. 11 AUGUST, 1952 No. 8

Cover—This U.S. Coast Guard photograph gives an overall picture of the outdoor exhibits at Bolling Air Force Base which were shown to the public by the various military services on May 17–18, 1952, in celebration of Armed Forces Day.

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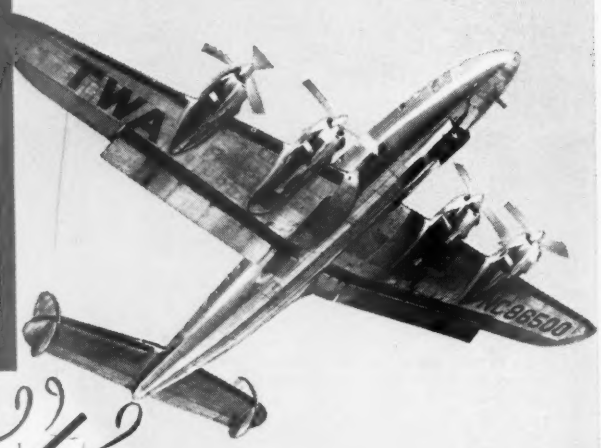
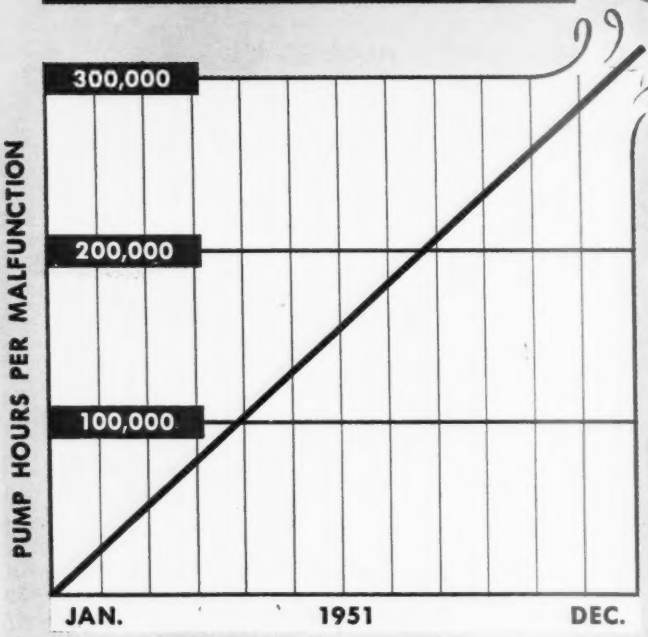
304,578 PUMP HOURS PER MALFUNCTION





There can be no question of the reliability and lasting qualities of Vickers equipment when it hangs up records like this. TWA maintenance records for 1951 indicate only one unscheduled removal of a Constellation cabin supercharger drive pump in a total of 304,578 pump hours.

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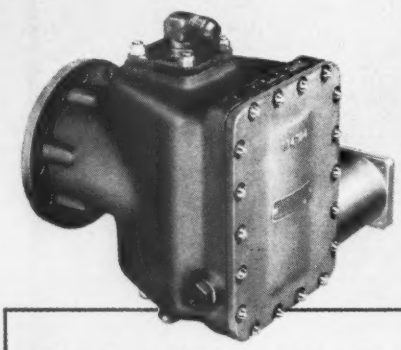


This is the reversible flow pump used in the Constellation supercharger drive, one of a wide variety of variable displacement piston type pumps available from Vickers. For further information write for new Bulletin A-5203.

4827

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

I. A. S. News

A Record of People and Events of Interest to Institute Members

Bane and Chanute Awards Presented

The Late Major Patrick L. Kelly, U.S.A.F., and Henry Seeler, of the Aero Medical Laboratory, Received The Thurman H. Bane Awards; John C. Seal, of Cornell Aeronautical Laboratory, Given The Octave Chanute Award. Presentations of Awards Made at I.A.S. Annual Summer Meeting Dinner on July 16 at the Los Angeles Ambassador Hotel

The Thurman H. Bane Awards for 1952

The Thurman H. Bane Award is normally presented to an officer or civilian of the Air Materiel Command for an outstanding achievement in aeronautical development. This year, however, the achievements of both an officer and a civilian of U.S.A.F. appeared to be of equal merit. It was, therefore, decided to give it individually to the late Major Patrick L. Kelly, U.S.A.F., and to Henry Seeler.

Major Patrick L. Kelly

Major Kelly was given the award posthumously "for developing techniques providing for artificial stability and control of aircraft during high performance phases of aircraft operation."

▸ **Stability and Control Compromise Problem**—As postwar requirements for aircraft performance steadily increased, Major Kelly noted a trend in current aircraft development to effect a compromise of both stability and control during the high-performance phases of aircraft operation. The automatic pilot per se, he observed, offered only a partial solution to the problem in that its augmentation was confined to stability.

▸ **A Solution Advanced**—To provide a generalized technique that would offer simultaneously a high order of stability and a high degree of maneuverability, Major Kelly conceived a technique by which stability could be introduced by an artificial means that would at the same time allow the complete utilization of the natural maneuverability of the aircraft. This was in 1948. He presented his plan to his superiors and before long received permission to initiate it as a project that was entitled "Operational Evaluation of Improved Flight Path Stability and Control" and of which he was named Project Leader.

▸ **New System Accepted by U.S.A.F.**—A system incorporating a combined control boost and automatic pilot was successfully reduced to practice, largely through the efforts of Major Kelly. It has now been adopted by the Air Force for use in another U.S.A.F. project and has been incorporated in three separate proposals for automatic pilots for development by the W.A.D.C.

The greater stability and maneuverability for aircraft which has been achieved because of this system and its adoption by the Air Force is considered to be the greatest advance in recent years in aircraft control.

▸ **Personal Background**—Major Kelly, who was born on January 1, 1922, and was killed in an aircraft accident on November 7, 1951, was appointed a Second Lieutenant in the Reserves in May, 1942. In November, 1947, he was appointed a First Lieutenant in the Regular Air Force component and about 3 years later was promoted to the grade of Major. His research on artificial stability was performed during his assignment to the All-Weather Flying Division, Wright-Patterson Air Force Base, Ohio.

Patrick L. Kelly

Henry Seeler

Mr. Seeler was named as the other recipient of The Thurman H. Bane Award for 1952 "for developing and standardizing a resuscitator, capable of operating at varying altitudes, for use in combat or evacuation aircraft."

▸ **A Simpler Resuscitator Wanted**—In the past, what resuscitators were available were of a complex design and demanded the services of a skilled technician who had had considerable instruction in their proper use. The need for a simpler one became a primary requirement. When, in 1950, the Aero Medical Laboratory was asked to develop and standardize such a resuscitator, one that could produce a satisfactory ventilation at altitudes as well as at sea level without undue complication of design or operating procedure, Mr. Seeler was assigned to the project.

Henry Seeler

▸ **Such a Unit Developed**—The unit subsequently developed by Mr. Seeler is of a design that can be operated on air, oxygen, or a mixture of the two. Required gas pressure is sufficiently low to permit the use of either compressed gas cylinders or a small compact blower type of compressor. The resuscitator can be adjusted to produce breathing cycles ranging in pressure extremes from a small negative value to positive pressures up to 30 mm. of mercury. Intermediate adjustments can be made to any desired range within these two extremes. This new resuscitator is of the pneumatic balance type and is compensated for the effect of altitude on the cycling rate, which varied considerably with altitude in previous models of this type. The only aid received by Mr. Seeler while he was developing this unit was in the fabrication of some parts by the local machine shops. This unit has many potential and practical uses in both civilian and military applications. Several manufacturers of oxygen equipment are seeking licenses to produce this resuscitator commercially.

▸ **Personal Background**—Mr. Seeler, who was born on January 23, 1907, in Luebeck, Germany, has been employed almost continuously during his professional career in the design and development of oxygen equipment.

In 1934, after approximately 9 years in industrial firms dealing in oxygen equipment and after receiving his engineering degree from the Society of German Engineers, Mr. Seeler joined the staff of the German Air Force Test Station as an Engineer for laboratory work and test flying. He remained in this position for 11 years and, during that time, had full responsibility for the design, development, testing, and standardization of oxygen regulators and oxygen masks within the German Air Force.

Mr. Seeler's initial employment under the auspices of the U.S. Government started at the U.S.A.F.'s Aero-Medical Center at Heidelberg, Germany. He began as an Engineer working on high-altitude oxygen equipment and prepared Chapter V-B in Vol. I of "German Aviation Medicine, World War II." He was transferred to the United States proper in 1947 and continued in the same line of work for the U.S.A.F. Mr. Seeler, who has applied for American citizenship, is currently employed by the Aero Medical Laboratory, W.A.D.C., Wright-Patterson Air Force Base, Ohio.

The Thurman H. Bane Award, endowed by Major R. H. Fleet, honors the memory of Col. Thurman H. Bane, one of the most prominent technical officers of the U.S. Army Air Corps, who died in 1932.

The Octave Chanute Award for 1952

John Clifford Seal, Chief Research Pilot, Flight Research Department, Cornell Aeronautical Laboratory, Inc., was selected as the recipient for The Octave Chanute Award for 1952 "for developing precise piloting techniques making possible fundamental research in full-scale dynamic stability and control, flutter, and structural loads determination."

▸ **Personal Background**—Mr. Seal, who was born 35 years ago in Minnesota, has spent the major portion of his life in the western part of New York State. In 1942, as an ex-Flight Instructor and ex-C.A.A. Flight Inspector, Mr. Seal joined Curtiss-Wright Corporation as an Experimental Pilot. After a time, the Curtiss-Wright Research Laboratory was established, and Mr. Seal was named its Chief Research Pilot. In 1946, he accepted a similar position, the one that he now holds, with Cornell Aeronautical Laboratory.

Having logged approximately 3,500 hours of actual research test flying, Mr. Seal has performed research flying on more than 50 types of aircraft and has flown over 100 different model versions of military aircraft.

▸ **Test-Flown Aircraft in Predetermined Conditions**—During his years with Curtiss-Wright and Cornell Aeronautical Laboratory Flight Research Departments, Mr. Seal has demonstrated an unerring belief in the ability of sound engineering analysis as a basis for flight research and a willingness to explore and exploit new research areas and techniques in flight on the basis of this belief. He has been able to produce exactly many difficult combinations of flight variables under severe boundary conditions, thus permitting the performance of research programs in régimes, or under circumstances, otherwise inaccessible or unjustifiable to an engineering research organization in terms of hazard and economics.

John C. Seal

▸ **Significant Test Flights**—Mr. Seal has flown innumerable test flights over the past years. Perhaps those flights that demonstrate most significantly Mr. Seal's ability and accomplishments are in connection with: (1) his long series of structural integrity, aeroelasticity, and dive demonstration tests on the Curtiss-Wright SB2C series wherein he consistently established predetermined test conditions under high acceleration with extremely unstable aircraft of negative stick force per g characteristcis; (2) the flight flutter program on the Chance Vought F4U-5, in which it was necessary to cut off the engine, feather the propeller, perform the test, and restart the engine on each flight; (3) the basic dynamic stability and control research utilizing specialized, automatic control and many new and untried techniques which extended over a whole series of aircraft including the B-25, A-26, F-80, N9M Flying Wing, etc. and which has formed a basis for the extraction of basic stability derivatives from the full scale; and (4) additional stability programs on the F4U-5 involving both artificial directional and rolling control and linear and nonlinear yaw dampers.

The Octave Chanute Award was established in 1939 by the Institute of the Aeronautical Sciences to honor the memory of Octave Chanute, pioneer American aeronautical investigator, who died in 1910.

Third Southeastern Regional Conference

On April 17 through 19, the Georgia Institute of Technology was host to the students and faculty from the University of Florida, Alabama Polytechnic Institute, Mississippi State College, Virginia Polytechnic Institute, Louisiana State University, and University of Alabama for the Third Southeastern Regional Conference of the Student Branches of the Institute of the Aeronautical Sciences.

The first of these conferences was inaugurated at the University of Alabama in April, 1950. The second one was held last year at the University of Florida.

Registration for the Third Southeastern Regional Conference got underway the evening of Wednesday, April 16, and continued the following morning. An informal luncheon at which George Kelbert, Chairman of the Georgia Tech Student Branch, spoke opened the conference proper. Papers were delivered by both students and faculty during the technical sessions.

The first technical session of the conference was begun at 1:45 p.m. on April 17 under the chairmanship of Mr. Kelbert. The following papers were presented: "A Vortex Meter for Flow Studies," by Richard Palatine and Jeffrey S. Deutsch, Virginia Polytechnic Institute; "Drag Reduction of a Magnus Cylinder," by Glen Nickerson, University of Florida; "Structural Aspects of Boundary Layer Control by Suction Through Perforated Skin," by Charles B. Cliett, Mississippi State College; and "Skin Temperature Problems at Supersonic Flight Speeds," by Bill Schleich, Georgia Tech.

The second technical session began at 9:00 a.m. the next day, April 18, and was presided over by Wesley Mann. The following papers were presented: "Aeronautical Engineering Employment Picture," by J. W. Hoover, University of Florida; "Fatigue of Aircraft Structures," by Richard J. Berman, University of Alabama; and "Structural Problems in Swept-Back Wing Design," by George K. Williams, Georgia Tech.

The group then adjourned to Lockheed Aircraft Corporation's Georgia Division at Marietta where they were welcomed by D. J. Haughton, Vice-President and General Manager, and R. W. Middlewood, Chief Engineer. Frank Johnson, Assistant Project Engineer on B-29 conversion, delivered a lecture on "Design Compromises." A tour of the plant was conducted during the afternoon.

A banquet was held that evening in the Officers' Club of the Atlanta, Ga., Naval Air Station with Donnell W. Dutton, Professor and Director, Daniel Guggenheim School of Aeronautics, Georgia Tech, presiding. Mr. Dutton first introduced the prominent guests and then introduced the guest speaker, Dr. Ernst Stuhlinger, a Scientist, formerly of Germany, who is now with the Army Ordnance Guided Missiles Development Center at Huntsville, Ala. Dr. Stuhlinger presented in his address a general background of the research done by the Germans and later by the United States. He then discussed not only the possibility but the probability of the construction of an earth satellite vehicle within the next decade. He defined the use of the satellite both from the military and scientific standpoints. After the banquet, a dance was given for the attending members and their guests.

The third and final technical session was held at 9:00 a.m. on Saturday morning, April 19. Mr. Kelbert presided at the session. The following papers were presented: "The Prediction of Transonic Pressure Distribution on Supersonic Two Dimensional Airfoils," by Jerry Hanson, Virginia Polytechnic Institute; and "The Story of Tullahoma," by Carl J. Wenzinger, Chief Aerodynamicist and Head, Aeronautical Department, Sverdrup & Parcel, Inc.

A business meeting followed by a tour of Georgia Tech's Aeronautics Department wound up the activities at the Third Southeastern Regional Conference.

Mississippi State College extended an invitation to the attending schools to hold the fourth in this series of conferences on the Mississippi State campus. This will, of course, be in the spring of 1953.

G. H. Dowty, R.Ae.S. President; I.A.S. Members Among R.Ae.S. Award Winners

George Herbert Dowty, F.R.Ae.S., A.F.I.A.S., Founder, Chairman, and Managing Director, Dowty Equipment Limited, England, has been elected President of the Royal Aeronautical Society (Great Britain) for the year, 1952–1953. He succeeds Major F. B. Halford, F.R.Ae.S., under whom Mr. Dowty served as an R.Ae.S. Vice-President.

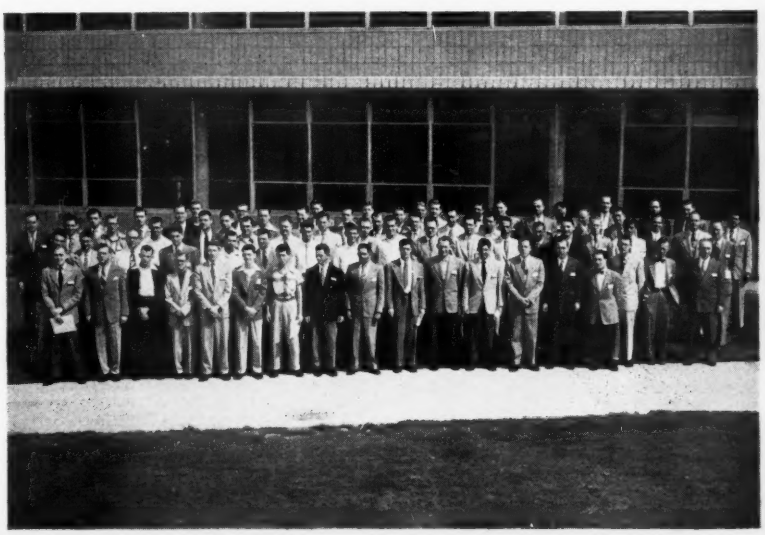
Simultaneously with the announcement of Mr. Dowty's election to the Presidency came the names of this year's R.Ae.S. award winners. Two of the ten award winners are members of the Institute of the Aeronautical Sciences—Dr. Theodore von Kármán, I.A.S. Honorary Fellow and Founder Member, who is presently Chairman, Advisory Group for Aeronautical Research and Development, North Atlantic Treaty Organization; and Handel Davies, A.F.I.A.S., Senior Principal Scientific Officer and Head, Aerodynamics Flight Section, Royal Aircraft Establishment, England.

Dr. von Kármán was awarded the R.Ae.S.'s top honor, the Gold Medal, for his outstanding work in aero-

(*Continued on page 54*)

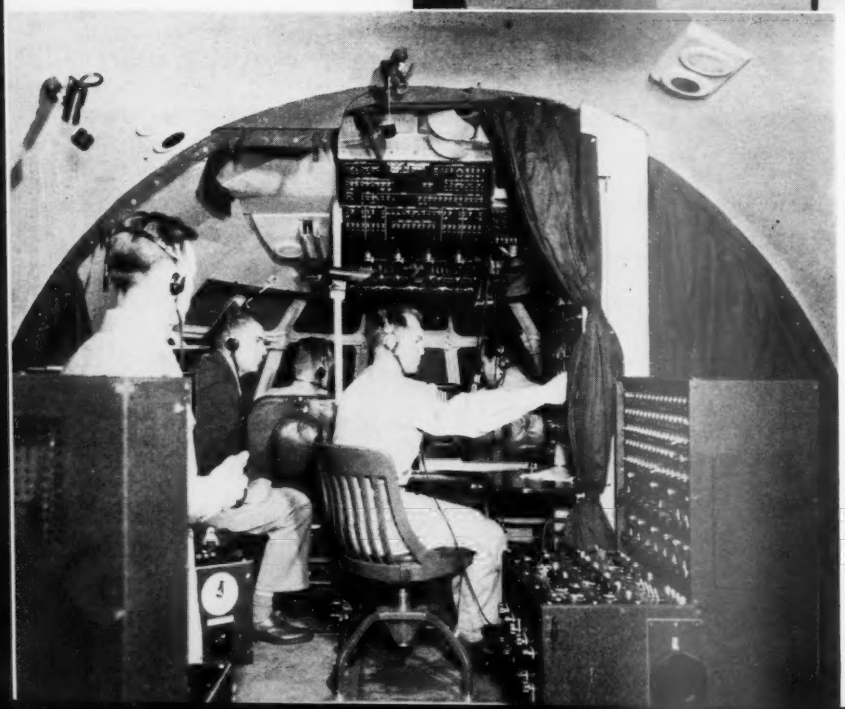
Student Conference Representatives

Representatives from various colleges and universities in the southeastern United States are shown during the Third Annual Southeastern Conference of the Student Branches of the Institute of Aeronautical Sciences. It was held on the campus of the Georgia Institute of Technology, April 17–19, 1952.

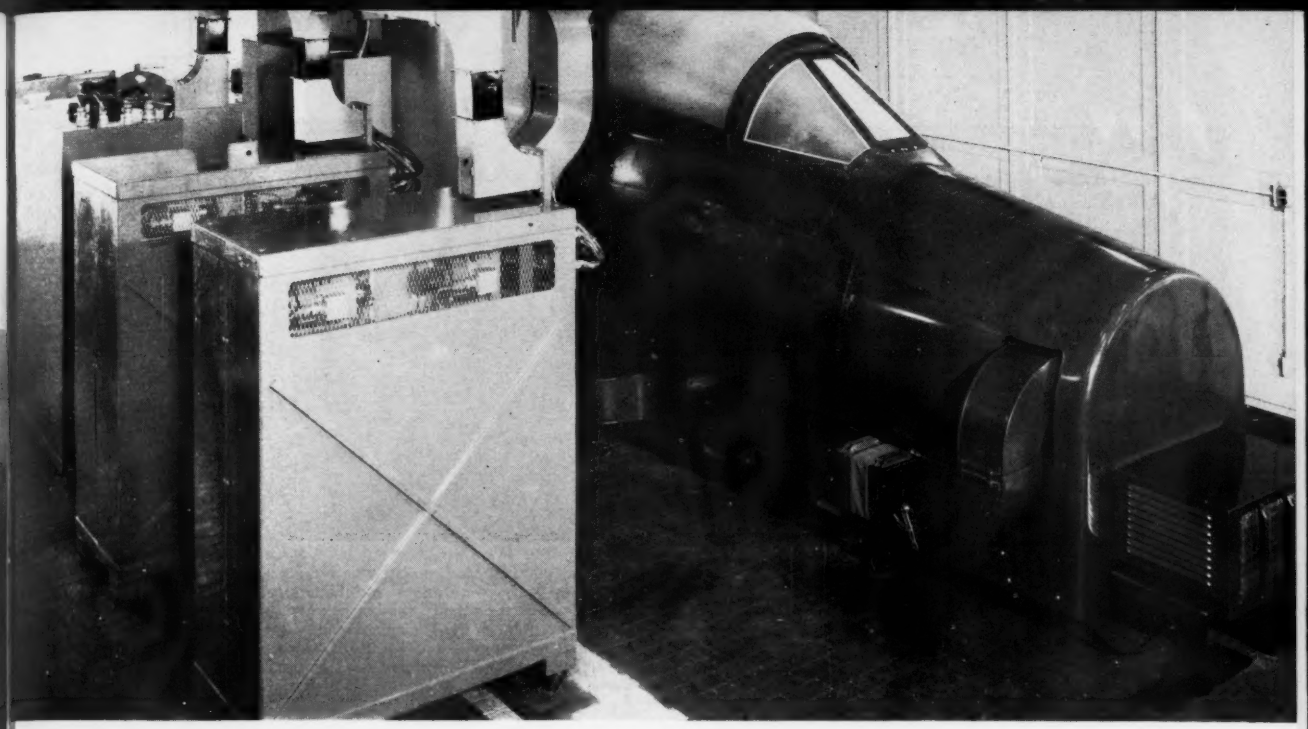


(*Left*) The early Link Trainer when fully instrumented and equipped with radio became an invaluable navigational training tool. *(U.S. Navy photo.)*

(*Right*) Latest Link—a B-47 Flight Simulator for the Air Force provides tandem cockpits for pilot and copilot, plus full complement of instruments and controls for the instructor *(left)*. *(Link Aviation photo.)*



(*Left*) First flight deck simulator in commercial use, the Dehmel-designed Curtiss-Wright 377, used by Pan American. Instructor is at left, rear. *(Curtiss-Wright photo.)*



A Jet Pilot Trainer—The McDonnell Banshee Simulator, designed and developed by Special Devices Center, U.S. Navy, and built by Curtiss-Wright. ***(Curtiss-Wright photo.)***

Editorial

Synthetic Training

The President's Airport Commission (see the REVIEW, July, 1952) pointed up the great potential of flight simulators as an aid to air safety, in general, and to safety in the vicinity of airports, in particular. The argument with respect to airports is not at all farfetched. Some of the accidents that precipitated the recent airport crisis arose from "unrehearsed emergencies" that confronted the pilots during take-off or landing. "An inadequately trained crew [was] faced with a problem for which it [had] no immediate answer." In such cases, time is seldom available for consultation or for reflective thought. Pilot reflex action is all that counts. Such action must be *instant* and *correct*, otherwise trouble looms.

In the days of small, slow airplanes, the rehearsal of emergencies in flight under properly controlled conditions was not particularly complicated, dangerous, or expensive. Now, however, with fast jets and multi-engined, million dollar transports, some substitute solution must be found to condition flight crews to produce the instant and correct reactions that are indispensable for maximum safety.

Fortunately, no one has to "invent" anything new at this stage. The idea goes back almost to the beginning of heavier-than-air history. Some early fliers thought they could get the "feel" of flight by balancing themselves on "seesaws." Later, a more practical man, Ed Link, produced his justly famous "trainer" on which most military and commercial pilots have spent hundreds of thousands of hours. Then, during World War II, under the guidance of Admiral de Florez, the Special Devices Center of the Navy went a long way in developing training gadgets of all kinds for airmen, pilots, gunners, and even submarines. (They are still hard at it today.) At the same time, Dr. Richard Dehmel, working at Curtiss-Wright, started a program that led to the installation of the first flight crew trainer for the Boeing 377 for Pan American World Airways.

As shown in the accompanying pictures, present-day flight simulators are complicated and expensive. They must reproduce accurately the instrumental responses of each type of aircraft under practically every flight condition. But their value is proved. The major problem for present solution is an economic one—"How can the people who need them afford the cost?"

Joint investment for common use by a group of air lines is one possibility. Installation and maintenance by the manufacturer, with a leasing arrangement to the user, is another. A third is the purchase and installation by a government agency.

Whatever method is adopted, some solution should be reached quickly. We think that the idea is important enough so that no airplane ought to be built for air-line service in the future without the design and construction of a crew trainer to go along with it to be available for the continuous use of all operators on some fair basis. Therein lies greater safety for people in the air and on the ground.

S. P. J.

The Promise and Problems of *Atomic Power*

GALE YOUNG*

Nuclear Development Associates

The author *(seated center)* discusses atomic power with E. W. (Pop) Cleveland, Vice-President and Director of The Cleveland Pneumatic Tool Company, and Chairman, I.A.S. Cleveland-Akron Section; Dr. R. P. Dinsmore, Vice-President, Goodyear Tire & Rubber Company; and Dr. Karl Arnstein, Vice-President—Engineering, Goodyear Aircraft Corporation. Mr. Young, who was associated with the development of the atomic bomb, is inspecting a model of Goodyear's latest blimp, the long-range N-1.

(1) Introduction

THE PAST YEAR appears to have been an eventful one for atomic power—probably the most significant period since the early wartime project days. In this paper, I shall consider some of the signs of the times and some of the manifestations that may possibly mark the long shadow of coming events, and include a few remarks about the application of atomic power to aircraft propulsion.

Nuclear fission was discovered only 13 years ago, and the tenth birthday of the atomic project has just been celebrated. Yet the A.E.C. enterprise in its totality has already become so large that I think it must in some manner concern almost everyone, whether he be a personnel manager trying to find scarce technical people, a technical man interested in an expanding new field, a procurement officer pondering where supplies and equipment go when they disappear from the market, a director interested in obtaining supplementary work projects for his company or laboratory, a Government official looking for contractors, or just a humble taxpayer.

(2) Magnitude of the A.E.C. Operations

Just what does this atomic enterprise look like at 10 years of age?

The total expenditure to date has been about $6,000,000,000, of which roughly half has been used while the other half is represented in the existing production plants and laboratories on hand. Thus the A.E.C. is today an enterprise with $3,000,000,000 in plant assets. While most of this investment is in outmoded plants and processes inherited from the wartime Manhattan District, it is probably largely this investment that has bought whatever measure of peace and time we have left today. Archaic as these plants and processes may be, they have stood almost alone between us and the aggressor's might.

These $3,000,000,000 in plant and equipment place the A.E.C. near the top of the list—along with A.T. & T. and U.S. Steel—among the great industrial enterprises. Its installations occupy some 3,000 square miles, an area about equal to the states of Rhode Island and Delaware combined, and its operations extend from the ore fields of the Belgian Congo to the weapon proving grounds of Eniwetok in the Pacific. It employs 120,000 people in its program, although only about 5 per cent of these are on direct A.E.C. payroll.

The present rate of expenditure is $1,800,000,000 per year, or about three times the average over the first 10 years. The A.E.C. is in the midst of an expansion that, when completed, will bring the total plant investment to $4,500,000,000. The two big current installations are the isotope separation plant at Paducah, Ky., and the plant at Savannah River, S.C., for making atomic bomb and hydrogen bomb materials. The investment in the Paducah and Savannah River plants combined will about equal the plant holdings ($1,800,000,000) of the General Motors Corporation; the Savannah River plant alone ($1,300,000,000) will somewhat exceed the total plant investment of the du Pont Company that is building the Savannah River installation for the Commission

It would clearly be impossible, in a paper of this kind, to do justice to the myriad engineering problems and details in an operation of this magnitude. Therefore, let me conclude this barest sketch of the A.E.C. enterprise with a few bits of comparative data about its use of scarce commodities, as shown in Table 1.

Presented at the Cleveland-Akron Section Meeting, I.A.S., Akron, Ohio, April 22, 1952.

* Technical Director.

TABLE 1

Commodity	Total U.S. Supply	Amount Used by A.E.C.	Per Cent of Total Used by A.E.C.
Nickel	....	....	7
Sulfur	....	....	5
Stainless-steel tubing	....	....	50
Electric power	....	....	2
Engineers	400,000	8,000*	2
Physicists	12,000	1,200	10
Total scientific and engineering population	....	....	5
Construction workers	3,000,000	60,000	2
Mathematical physicists and nuclear physicists	350		

* One-quarter mechanical, one-quarter electrical and radio, and smaller numbers in other engineering categories.

These numbers are current values, and all are rising and will rise further even without any A.E.C. expansion over and beyond what was already underway at the end of 1951. Thus, the more recent proposals for a severalfold new expansion of the A.E.C. program would presumably call for something like a severalfold multiplication of percentages in Table 1.

A singularly unhappy note is that struck by the item concerning electric power. In spite of the 100 kw. of electrical energy recently produced from a reactor at Arco, it appears that the books and face of the atomic business are much in the red on the subject of power. To quote Commission Chairman Dean:[1,2] "The atomic energy program is consuming power at a rate which by next June will be comparable to that of New York City, or roughly 2 per cent of the total national supply, and this demand will increase enormously as additional new plants now under construction come in. For example, our new uranium separation plant now being built at Paducah, Kentucky, will have a power demand of about 1,000,000 kw. . . . The fact remains that while the world ultimately looks to the atom to produce power the atomic energy program is today the largest single *consumer* of power. . . ."

(3) Recent Events of Significance for Atomic Power

(3.1) Projected Expansion of A.E.C.

There have been recent proposals for vast further expansion of the atomic program. Senator McMahon, Chairman of the Joint Congressional Committee on Atomic Energy, last year introduced a resolution into Congress urging that the program be raised to a $6,000,000,000 annual rate. His Committee requested the A.E.C. and the Department of Defense to prepare a detailed program for maximum expansion of the program. Subsequently, President Truman indicated that a new $5,000,000,000 or $6,000,000,000 expansion in A.E.C. facilities is contemplated during the next several years;* added to the $4,500,000,000 in plants which will exist at the completion of the present phase of expansion, this gives the A.E.C. a $10,000,000,000 total plant investment in the future.

Thus, the atomic program is apparently going to be expanded as fast as it can absorb funds poured into it. While this expansion is motivated by weapon needs, it must surely be of significance for atomic power as well. Even if this money were to be spent entirely in duplicating the venerable outmoded plants that the A.E.C. operates today (the isotope separate plants that sop up huge quantities of power instead of producing it and the Hanford reactors that throw their heat away uselessly down the Columbia river—both of them merely skimming a little of the top cream off the costly uranium ore before discarding it to waste†), it would

* Marking the beginning of this expansion is a current announcement by the A.E.C. that it is looking for a site for another isotope separation plant to cost $1,000,000,000 and to consume 1,800,000 kw. of electrical power.

† The Savannah River plant is similar in nature to the Hanford facility.

Photo Courtesy Argonne National Laboratory

The machine shop in the building housing the new Experimental Breeder Reactor at the Atomic Energy Commission's National Reactor Testing Station in Idaho is shown lighted by, and operated on, electric power produced from the heat energy of the reactor. The reactor and its power plant were built and designed by the A.E.C.'s Argonne National Laboratory.

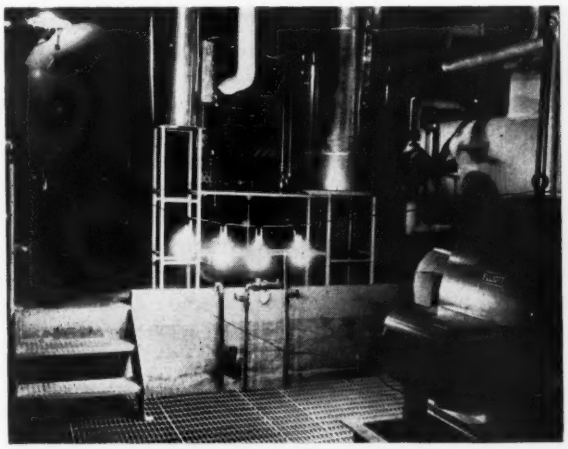


Photo Courtesy Argonne National Laboratory

The electric light bulbs in this photo show the first known use of electric power from atomic energy. The bulbs are lighted from electricity produced by the generator at the right which, in turn, operates on heat from the recently completed Experimental Breeder Reactor.

surely benefit atomic power. You cannot spend that much money on anything atomic and bring into the program that many bright engineers, physicists, etc., without getting additional ideas and know-how. There must be at least some minimum measure of atomic-power significance attached to the coming A.E.C. expansion.

Actually, the Commission has lately indicated that it is on the trail of much more advanced processes (breeder reactors), and, if some substantial fraction of the coming expansion can go into this new kind of plant, the significance will be greatly increased.

(3.2) *Mobile Reactor Progress*

The most positive and definite assurance of atomic power, at least in some limited form, comes from the mobile reactor program being undertaken for military vehicles. It has been known for some time that work was under way on reactors for the propulsion of submarines and aircraft. This past year saw unmistakable signs of progress and decision in both endeavors.

In the submarine department (where Captain H. G. Rickover has had a strong guiding hand throughout), there are two major branches. One involves the Argonne National Laboratory and the Westinghouse Electric Corporation, and the other is at the General Electric Company. The Argonne-Westinghouse reactor appears to be far along indeed. Construction of the first land-based prototype at the Arco test station has been under way for some time, and the Navy has contracted with the Electric Boat Company to construct the hull for the first submarine proper (which the Navy has already named the U.S.S. "Nautilus" and expects to have ready in 1954). The General Electric reactor is also to be first operated as a land-base prototype.

In the aircraft department, there were several important developments during 1951. It was announced that the N.E.P.A. (Nuclear Energy for the Propulsion of Aircraft) preliminary study project had finished its work. Contracts were given by the A.E.C. and the Air Force to the General Electric Aircraft Gas Turbine Department to construct the reactor and power plant for an airplane, while the Air Force contact for construction of the corresponding air frame went to the Consolidated Vultee Aircraft Corporation. This was big news in the aircraft atomic propulsion business; these were major companies, and they were being given major contracts actually to build a flying machine. Clearly, there was something in the wind. Then came the news at the end of the year that Pratt & Whitney had been given an Air Force contract to develop another and different aircraft reactor and power plant.* Let us again quote Chairman Dean who says:[3]

"We are much farther along on the submarine reactor than we are on the aircraft one, but I am sure in my own mind that eventually we are going to have both; and as a special bonus we are going to pick up a lot of technical know-how that will help us immeasurably in cutting the costs of atomic power for commercial use. What we are doing, essentially, is charging a good share of the high development costs of power reactors to national security, and, in the process, getting at the earliest date possible a kind of propulsion unit that will reduce almost to the vanishing point the dependence of naval vessels and military aircraft upon bases of fuel supply."

(3.3) *Entry of Industrial Companies into the Atomic-Power Field*

The mobile reactor developments assure us, as much as anything can be assured in a new field, that there is going to be some use of atomic energy for power purposes—namely, to drive military vehicles. But this is not what the man in the street means by atomic power. He means something that will bring electricity into his home economically or be of service in his peacetime industries. As the above quotation from Chairman Dean indicates, this latter is a less immediate prospect.

However, even here there are important deevlopments. This past year has seen four teams of industrial companies, under arrangement with the A.E.C., start spending their own money—at least $1,000,000—in atomic-power studies. There is a Michigan team (Dow Chemical and Detroit Edison), a St. Louis team (Monsanto Chemical and Union Electric), a California team (Bechtel and Pacific Gas & Electric), and a Chicago team (Commonwealth Edison and Public Service). The agreements provide for surveys and studies by the companies (a) to determine the engineering feasibility of their designing, constructing, and operating dual-purpose reactors to produce fissionable materials and power; (b) to examine the economic and technical aspects of building such reactors in the next few years; (c) to determine the possible research and development needed; and (d) to recommend industry's role in designing, building, and operating such reactors.

Commissioner Glennan comments:[4] "What will they come up with? I don't know but I am satisfied that much of value will appear in their reports. You just can't let intelligent, aggressive engineers and management people loose in this business and draw a blank as a result of their efforts. No one of these companies will willingly throw away the money they are spending on these surveys. As a minimum, then, let's say that I am more than mildly enthusiastic on this deal."

(3.4) *Breeder Reactor Announcement*

The past year saw several news items about peacetime applications of atomic energy. The British project revealed that it is using reactor output for the space heating of buildings. The A.E.C. announced that the Argonne National Laboratory had produced the first known electrical power (100 kw.) from a reactor; the Commission's report[5] shows photographs (reproduced herein) taken by the light of this electricity.

* It has been further announced that Boeing is to work on an air frame in connection with the Pratt & Whitney engine project.

Subsequently, Oak Ridge National Laboratory disclosed that it too, has a reactor under construction which will generate some electrical energy. These developments are encouraging, but I doubt if they carry much significance in themselves. To the public, which has been awaiting such news for a long time, the principal connotation is merely a feeling of relief that these announcements have come at last. But, while somewhat playing down the significance of the power announcement as such, I would emphasize strongly another aspect of the same story—namely, it was an experimental *breeder reactor* from which this power was produced. Herein lies the real significance of the announcement, and here lies the real road to the future.

You will recall that the fission chain reactor is possible only because a fission, which uses up one neutron, in turn produces more than one neutron. Thus, the neutron output from one fission suffices to set off the next fission, etc. Thus, if one has a supply of fissionable material, one can proceed to burn it via the neutron chain and so obtain energy. This is what the project has been doing thus far. Some fissionable material—namely, the rare isotope 235 of uranium—is found in nature in tiny amounts, and the project consumes this to produce energy in atomic bombs, mobile reactors, etc., by the now familiar processes developed in the Manhattan District under General Groves.

The new breeding process being developed by the A.E.C. goes much further and makes each fission replace not only the consumed neutron but also the consumed atom of fissionable material as well. This is possible because, first, each fission produces two and one-half neutrons* so that, even after you subtract the one neutron needed for the next fission, there are one and one-half neutrons left; second, if you have a neutron, you can make an atom of fissionable material by absorbing the neutron in a so-called fertile material. Thus, if you are careful not to waste any neutrons in the process (which is one of the big development problems, since neutrons tend to be absorbed by anything and everything you put in the reactor for structure, cooling, etc.), you can make one and one-half atoms of fissionable material for each one you destroy. Hence, your breeder reactor not only sustains itself on fissionable material, but continuously exports an excess of one fuel atom for each two it consumes.

Here, then, is the coming facility that makes obsolete the plants that the A.E.C. is today operating—a power-producing breeder reactor (either stationary for industrial use or mobile for military or transportation purposes) which steadily exports fissionable material for weapons or other use. The required fertile materials (uranium 238 and thorium 232) exist in nature in much (several hundred times) greater abundance than the natural fissionable material (uranium 235) now being exploited. Thus, the breeder reactor enables us to expand the atomic program a hundredfold, if desired, and, at the same time, be freed from depending upon foreign ore supplies in remote and vulnerable corners of the world.

This is a key development that warrants the greatest all-out effort. Senator McMahon, who sounded the first note in the vast new expansion of the atomic energy program, says in the 1951 report of his Joint Congressional Atomic Energy Committee:[6] "The Committee also renews its 1949 recommendation, particularly as regards thorium breeders and plutonium production reactors of the future, that 'reactor development . . . proceed with all possible speed.' . . . there are opportunities for faster advancement which need to be vigorously exploited. If the Committee has a single general comment to offer, it is this: Greater boldness and more scientific and technical daring should be brought to bear upon the program."

Thus, the first power came from an experimental breeder reactor and in this is a manifestation of the boldness and daring Senator McMahon urged. As people interested in the development of atomic power, as citizens who want our atomic program to be of the best and our country to be in the strongest position possible, and as taxpayers who do not want to see the nation saddled with any more billions of dollars worth of antiquated atomic plants than necessary, let us hope for the continued fast advancement and vigorous exploitation that will see breeder reactors playing a major role in the coming new expansion.

(4) Major Problems

Having reported to you on some of the more significant atomic power news of the last year, next, I should like to distinguish some of the larger problem areas and make a few comments on some of the more specific topics involved. Various of the frequently encountered technical items have often been described in the literature. For example, Dr. Hafstad[7] notes the inability of materials to stand high temperatures, show minimum radiation damage (under the intense bombardment of neutrons, gamma rays, etc., in the interior of a reactor), and not absorb and waste an excessive proportion of the available neutrons. He also notes the problems of shielding personnel and instruments against the adverse effects of radiation, obtaining control gear with response times adequate for safety, effecting heat-transfer rates higher by an order of magnitude than those conventionally used, dealing with fission products that jeopardize neutron economy, and handling and ultimately disposing of radioactive waste in a manner that will constitute the minimum health hazard.

(4.1) Raw Materials

The starting point of atomic energy work lies, of course, with the raw materials (uranium and thorium) employed. The emphasis to date has been primarily on uranium, which already contains a small fraction of fissionable material (one part in 140) which can be

* The A.E.C. has just revealed that under some conditions the number of neutrons per fission is as large as three, which improves the breeding picture given here.

exploited, rather than on thorium, which can be utilized only in a breeding process. These raw materials are radioactive and are slowly decaying and will eventually turn into lead. There need be no concern that atomic power may not be developed before the raw materials are lost. This worry is completely unjustified, since these materials take a few billion years to decay, and we are assuredly making progress much more rapidly than that.

Estimates of uranium in the earth's crust run from three to eight parts per million by weight and for thorium from ten to 30 parts per million. Using nominal values of 5 for uranium and 15 for thorium gives a total of 20 parts per million. Since the energy output per unit weight is about 2,500,000 times as great for fissionable material as for coal, we see that a ton of average earth crust is potentially equivalent (assuming breeding to utilize fully the raw material) to 50 tons of coal. (See similar remarks by Akers.[8])

Granting that the earth we walk on is energywise 50 times as rich as a solid bed of coal, what about the costs of extracting materials? On this, only the roughest of estimates are available. Menke,[9] from a survey of costs in a number of other cases, has estimated the price of extracted materials to be about $10 per ton of ore handled. Using this as a guess sounds encouraging, since it would say that the energy equivalent of 50 tons of coal can be obtained for $10, even if we ignore the value of any by-products obtained in processing the earth's crust. Similar suggestions have been made for "mining" sea water. Here, the uranium and thorium concentrations are much lower.

The above values of $10 per ton at 20 parts-per-million concentration would give a cost of $250 per lb. for uranium and thorium recovered from average earth-crust ore. From richer-than-average ore the cost should, of course, be correspondingly lower. While I do not believe full data on A.E.C. uranium costs have been published, price schedules paid to miners for ore have been published, and these go up* to several dollars per pound of contained uranium. A Canadian article[10] discusses the process used in extracting the uranium from the ore and implies costs of a few dollars per pound of uranium for this separation step. Adding "several" to "a few" gives approximately $10 per lb. as an estimate for the current price of uranium.

A cost of $10 per pound marks a fairly expensive material, and, needless to say, the procurement of raw materials for the project is a big business dollarwise. Since the prospecting, as well as the mining and concentrating, of the basic raw materials is one of the major areas for the application of engineering effort and ingenuity, I should like to call it to your attention.

Extensive exploration work is under way to locate further deposits, and recovery of uranium from gold ore residues in South Africa and from fertilizer phosphate rock in the United States has been announced.

* Including bonuses, development allowances, transportation allowances, etc.

Some of the darker parts of the picture are: (1) The breeding process is not yet in hand, and, without it, the raw material situation is immediately some 500 times worse. (2) Atomic power is at peculiar disadvantage with respect to the inventory of material which has to be on hand. You are doubtless familiar with the phenomenon of "critical mass" which has been frequently discussed—namely, that a small amount of fissionable material will not operate by itself and that a large amount of fuel must be assembled in order to get a chain reaction at all. Much the same sort of thing applies also in breeding and for much the same reasons. It is easy enough to say that we shall capture the excess neutrons in fertile material and thus make fissionable fuel; however, the neutrons tend to diffuse for considerable distances and thus escape from the system, and they also tend to get uselessly absorbed in other material in the system. Thus, to capture the neutrons effectively in practice requires the use of a large amount of the desired capturing (i.e., the fertile) material.

I do not have an especially good example to illustrate this point, but we can get a quantitative impression by looking at the famous Canadian reactor that was announced as having the highest neutron flux in the world. I always thought it was the atomic news story of the year when Dr. Hafstad revealed, 3 years ago, that the Canadians had a higher intensity reactor than we possessed, but it did not seem to bring forth much comment in the press. Perhaps Dr. Hafstad dropped his bombshell too quietly, or perhaps there was at the time too much heated discussion about whether we were properly keeping our atomic secrets. However, the news that we had slipped to second place in an important respect went apparently almost unnoticed. So far as I know we still do not have a reactor to match the Canadian machine. This Canadian reactor has a flux of 6×10^{13} neutrons per square centimeter per second, and an atom of fissionable material has a cross section or target area for neutrons of about 500×10^{-24} cm.^{2}. Upon multiplying these numbers together, it is seen that 3×10^{-8} of the fissionable atoms are hit by a neutron in 1 sec. It follows that the reactor contains $^1/_3 \times 10^8$ sec. or about 1 year's supply of fissionable material. Since this is a natural uranium reactor, the amount of fertile material is 140 times greater, or a 140 years' supply for a breeding process.

With such huge inventories, even a low-price fuel can become a major investment item. If the holdup time is 140 years and the fixed charges (interest, insurance, taxes, etc.) are 7 per cent annually, then the inventory cost is ten times the destruction cost. Such numbers indicate that the search for richer ore deposits or cheaper mining methods may be spurred more by inventory requirements than by the cost of fuel destroyed. This factor of 10 suggests† that breeding

† This holdup cost factor of 10 does not apply at present when we have a large stockpile of fertile material (depleted uranium from the project) which is idle.

is 50 (rather than 500) times better on raw material charges than simple exploitation of the natural fissionable material; the "holdup" factor of 10 obtained here is only a rough impression and is, of course, subject to improvement through design effort—e.g., raising the neutron flux would decrease the holdup time.

In any case, I would like to leave with you as a first major engineering problem and challenge the mining of increased quantities of raw materials at lower prices. It is a most important area and can be a highly rewarding one. Dr. C. E. Larson, Director of Oak Ridge National Laboratory, was recently quoted[11] as saying that the future of atomic development in the United States depends on recovery of uranium from low-grade ores.

(4.2) *Aircraft Reactors*

As was mentioned earlier, the mobile reactor program has at present two substantial branches concerned, respectively, with submarines and with airplanes. Of these two, I shall deal primarily with the airplane program.

These two reactor programs have been under way for about the same length of time, and the submarine development is farther along primarily because it is the less difficult of the two. The atomic-powered airplane is an extremely difficult development. Indeed, it seems fair to say that, with the possible exception of economical commercial atomic power itself, the airplane problem is the most difficult one the project has. The difficulties encountered in the aircraft program have been described by Dr. M. C. Leverett, of the General Electric Aircraft Nuclear Propulsion Project, in a talk before the I.A.S. Chicago Section about 6 months ago.[12] They stem largely from the large shield weights required by reactors and the high temperatures required by airplane power plants. Dr. Leverett indicates that the necessary shield weight is some 50 to 100 tons, which is just about what can be carried by the largest airplanes in existence. Such large planes require large power outputs to propel them, and, thus, the reactor, which has meantime been made small in order to keep down the weight of the shield surrounding it, winds up in the unhappy position of having to generate and remove large amounts of heat from a small volume. This particular difficulty is known as *high specific power* (i.e., high power output required per unit reactor volume) and is possessed by the aircraft reactor to an uncommon degree. You can readily picture the horde of troubles that this engenders—fine scale structure, high coolant velocities, large pressure drops, high heat fluxes, and large temperature differences, thermal stresses, etc.

A reactor for aircraft service is also caught in the cross fire of a second major difficulty, namely, the uncommonly *high temperature* called for in this application. The problems encountered in pushing materials up to the temperatures reached in modern military aircraft power plants are familiar. The same problem is encountered in the reactor, except that (a) every time you propose a material to put into the reactor there will be somebody who wants to take it out because it absorbs too many neutrons, and (b) people will insist on putting into the reactor materials of which you have never heard.

Dr. Leverett remarks that just about every type of aircraft propulsion machinery has been proposed for use with a reactor but does not indicate what the actual choice will be. On this point, I recall only two authoritative statements. About 2 years ago, Dr. Andrew Kalitinsky, who was at the time Chief Engineer of the N.E.P.A. project, told a meeting of the I.A.S. that a turbojet system might be the easiest way of applying atomic power to aircraft. When it was announced last year that the first design contact in this field had been given to the G-E Aircraft Gas Turbine Department—a division that specializes in turbojet engines—it seemed for a while that this supported Kalitinsky's opinion. However, just 2 months ago this year, Dr. Alvin Weinberg, Research Director of Oak Ridge National Laboratory, was quoted[11] as indicating that, as far as present thinking went, an atomic aircraft engine would probably deliver power through a steam turbine.

(4.3) *Breeder Reactors*

The main theme of what remains to be discussed concerns the problem of economy, and this will serve also to point out the close tie-in of the subject of breeding with my next topic of industrial power.

In a breeder reactor, the neutrons released by a fission go (a) to replace the neutron consumed in the fission and (b) to replace (or more than replace) the fuel atom consumed in the fission via neutron capture in fertile material to produce fissionable material. It is thus clear that neutron economy will be of much concern and that no large loss of neutrons by useless parasitic capture in reactor materials can be tolerated.

Another point to be noted is that things have to be done to the fertile material and operations carried out on it before it becomes fissionable material. Thus, if the raw material could be mined directly in fissionable form instead of in fertile form that has to be processed further, it would certainly be cheaper than breeding. Unfortunately this is not the case, and only a small fraction (1 part in 500) of the raw material is naturally fissionable. The present project operations amount to seizing upon and exploiting this small fraction of the raw material, the remaining large fraction being essentially discarded. Even this small fraction is not available free after the ore has been obtained, and further processing, such as in the expensive power-consuming isotope separation plants, is needed before pure fissionable material is obtained.

Thus we see that breeding gets unavoidably into the large question of dollar economy. The processes it involves must not only be developed but they must be developed so that they can be carried out economically.

In situations of this sort, the primitive operation (in the present case, our exploitation of U 235 by the methods of the Manhattan District) can get so entrenched behind big plant investments, etc., that the desirable ultimate operation can even be inhibited or discouraged, with the money continuing to go into what was done yesterday instead of into what should be done tomorrow.

While the Commission's announcement of the Argonne breeder reactor is careful to say that it is only an experimental machine and that much further development is needed, let us continue to hope that this is nonetheless a sign that we are breaking out of the Manhattan District's primitive U 235 trap and that the road to tomorrow is being blazed with all possible vigor and determination.

Nothing short of true breeding can achieve the goal of multiplying our raw material stockpile by factors like 100 and assure us of a sufficient supply for all conceivable military developments and industrial power advances. It is, in passing, a little ironical to note that the bred fuels (U 233 and Pu 239) are the ones that are potentially available in large amounts and that the one (U 235) whose tiny amount we are so busy using up is the one that will be most difficult to replace.

(4.4) *Industrial Power*

What now, finally, of the big question that the man in the street has been asking for so long—Is there going to be commercial atomic power? This question has been debated at such length and with such vigor that it would be difficult to have any new opinions about it. The real inside information on this is fortunately not secret and can be conveniently assembled in the following statement. "Atomic power will be economical if you can make it cheap enough."

This remark serves to set the stage for the coming development battle for atomic power—a battle that is just now being joined and which will be won or lost largely in terms of success in cutting costs and finding more economical processes.

I have mentioned the many diverse opinions that have been expressed about the outcome of this struggle and about the prospects for atomic power. Let me give you two contrasts and a few singletons from among these.

Last September at the Chemical Society meetings in New York, two eminent gentlemen spoke on this subject. Dr. Conant, of Harvard,[13] upheld the negative and pictured the atomic-power game as turning out about a decade from now to be not worth the candle, with worried mankind eventually finding a way out of the atomic age and into an age-of-plenty based on solar energy. He spoke of the worry about coal supplies as increasing by the end of this century. On the other hand, Dr. Grebe, of Dow Chemical Company (who is one of the men participating in the current atomic power studies by industrial companies mentioned earlier), sees[14] a serious situation looming now in the electrical power field where mounting costs have finally overtaken engineering ingenuity, with the result that power prices, which have been continually going down for years, have at last started back upward. He fears that this reversal in trend of such a basic commodity as power will have an adverse effect on our national productivity and looks to atomic power to tip the scales the other way and "help make possible the continuation of the remarkable growth curve of the United States." He remarks that "the rapid increase in total heat energy consumption, particularly the electrical power production, now doubling every 9 years, can no longer be supplied from the current rate of production of coal," and, thus, further increases in the already high prices of coal are to be expected.

For a second, and much milder, contrast let me go back to 1948 when two other eminent gentlemen (physicists, this time) spoke on these same subjects. Professor Wigner, of Princeton,[15] did not expect atomic power to assume any decisive economic importance so long as the present period of abundance of fossil fuels continues, and, even when these near exhaustion, it will have to compete with other sources such as solar energy. Professor Pryce, of Oxford,[16] on the other hand, expresses hope that atomic power may come along quickly enough to provide some relief of the present fossil fuel shortage and that the atomic raw materials may "last sufficiently long to allow human ingenuity to find new sources of power before they run out."

Many of the differences in these several points of view appear to arise from different opinions as to the fossil fuel resources, with the British and the engineers being more pessimistic on this score and American scientists more optimistic. Dr. Grebe in fact remarks that the British should lead in the early production of atomic power because they need it more.

Let us note now an opinion from Canada (where, as I mentioned earlier, the world's most advanced reactor has been in operation for some time). Two years ago Canadian scientists believed significant civilian use of atomic energy was from 20 to 30 years away. By 2 months ago, they had changed their minds. The government formed a Crown Company, Atomic Energy of Canada, Ltd., to take over the Chalk River project in Ontario, the main center of atomic research. Prime Minister Louis St. Laurent announced: "The prospects for early and useful application of atomic energy have become more promising."

Finally, about 1 month ago, Chairman Dean of the U.S.A.E.C. offered a guess that atomic energy might be used for limited commercial electric power production within 5 to 10 years.

All this appears to be showing signs of adding up to something. In atomic circles, there is a quickening of interest all along the line and a heightened feeling of vigor and boldness and of things impending. I am not sure just what has brought this about. Perhaps it was triggered, as much as by anything, by a proposal of Dr. Charles Thomas, President of Monsanto Chemical Company. Dr. Thomas suggested that, since in-

dustry wants power and the A.E.C. wants fissionable material and since reactors can produce both, the two might get together in some way, with industry building and operating reactors for power and the A.E.C. purchasing the resulting fissionable material at a price that would make the operation feasible. This idea seemed to have appeal all around, and it was not long before the A.E.C. had completed arrangements with a number of companies (including that of Dr. Thomas) to look into the possibility. Thus, the atomic-power studies by the four industrial teams mentioned previously were begun.

Dr. Grebe's paper[14] represents the only report we have had from the industrial studies. After expressing his concern about the deteriorating fossil fuel and power situation, as I mentioned earlier, Dr. Grebe goes on to discuss the prospects for atomic power development.

The main theme of Dr. Grebe's paper is "invent cheaper processes—drive costs down," and this same theme runs through many other discussions of the subject.

Why, then, are the atomic power costs so high? Perhaps in closing I can attempt to give you some idea of the high costs about which everyone is so concerned. Undoubtedly, a large share of these costs stems from a single word—*radiation*. If it were not for the dangerous radiations involved or if we were somehow immune to these radiations, we might have atomic power now. Imagine, if you will, that the aircraft engines with which you are familar could only be operated within thick vaults and that everything in them became intensely radioactive, and I think you will get some idea of what the reactor engineer is up against. The difficulties of remote-control engineering have been well stressed by Dr. Simpson;[17] you have merely to translate these into costs in dollars and time to see why the project is both slow and expensive. Even the simplest of operations—e.g., tightening a bolt—can become inordinately expensive and time-consuming if it has to be done by remote control through a thick wall of a building or by a man working from within a heavy crane cab.

Reactors will not let you go away and ignore their unpleasant contents. To quote from former Chairman Lilienthal:[18] "When fission takes place energy is released. . . . But something is left behind, the result of splitting the nucleus. This mixture of the isotopes of many elements is very radioactive. Inside the reactor, where all this takes place, the effect of these 'hot' elements on the operation of the reactor is bad. Some of the new elements absorb neutrons readily, so that their effect is to quench the nuclear reaction. The fission products—the nuclear ashes—must be removed and the remaining nuclear fuel recovered to be used again. This is a chemical separation job that presents some highly complex and difficult problems of chemistry, chemical engineering, and metallurgy—and it must be carried out by remote control to protect the workers from lethal radiations. I need not stress the troubles of this kind of operation by mechanical proxy, nor need I stress the economic importance of efficient recovery of the unspent nuclear fuel, for this is material that may not under any circumstances be wasted."

In briefest sketch, then, we can outline the operations and problems of an atomic power plant as follows. First, one obtains the raw material—the fertile material that turns into fissionable material when it captures neutrons. Evidently, this material has to be arranged so as to surround completely the part of the reactor where the fissions occur, or else neutrons would escape and be lost. This surrounding outer layer of fertile material is commonly called the "breeding blanket," and the central region where the fissions occur is termed the "core" of the reactor. The blanket has to be thick enough to catch all the excess neutrons leaving the core, and it has to be cooled without introducing neutron absorbers to any significant extent; there is a high premium on neutron economy in a breeder reactor. Now we come to the "processing" headache so vividly described by Mr. Lilienthal. The fuel is created in the blanket, and we want to remove it for export or to transfer it to the core where it is burned. This must be done in spite of the intense radioactivity; it must be done without losing precious fuel or fertile material, and it must be done economically. How it is, in fact, going to be done, I have no idea, but some day engineers will figure it out and then we will have atomic power.

After the fuel has entered the core, much the same applies. It must be cooled (more strongly now, because here is where most of the heat is produced) without wasting neutrons; it has to be processed over and over again to remove fission products, again economically in spite of the intense radioactivity and without wasting fuel.

Because a breeder with its associated fertile and fissionable material is an expensive machine, as much power as possible must be extracted from it. Thus you will again be led into the high specific power difficulties I mentioned in connection with aircraft reactors. Also, since you will want good efficiency in your power plants, you will be led into the problems associated with high reactor temperatures. Thus, in these respects, more or less, what must be done in getting an aircraft reactor must be done again, except that this time it must be done economically. Then we will have atomic power.

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(*Concluded on page 52*)

The Forecasting of Jet-Aircraft Condensation Trails

H. APPLEMAN*
Air Weather Service

(1) Introduction

An airplane leaves a condensation trail (contrail) when, by aerodynamic cooling or by the addition of moisture from the exhaust, it causes supersaturation of the environment through which it is passing. These trails form more readily and are more persistent under certain meteorological conditions than under others. If these conditions are known, a forecaster can advise the pilot as to the flight altitudes at which the contrails are least likely to form.

From an operational point of view, the formation of condensation trails gives rise to two hazards. First, when a large number of aircraft rendezvous at a given point over a fairly long period of time, the contrails given off may form a cloud sufficiently dense to interfere seriously with the operation. The selection of another level for the rendezvous might eliminate such clouds completely or at least result in a decrease in their density.

The second danger from contrails is that of detection by the enemy. With the perfection of radar warning systems, this is not so serious as formerly. However, radar networks are never perfect over great areas, and visual observation will continue to supplement radar detection in any aircraft warning system. In addition, careful observation of contrails frequently can give more information as to the number and type of aircraft than can be obtained from the radar scopes.

(2) Aerodynamic Trails

Aerodynamic trails are caused by the momentary reduction of pressure when air flows past an airplane. This results in adiabatic cooling of the air, which may be great enough to raise the relative humidity of the affected environment to 100 per cent or more. In such cases, condensation will occur, and, if enough liquid water is produced, a visible trail will form.

The local decrease of pressure varies greatly with the part of the airplane in question. It has been reported as great as 170 mb. on the top of the wing and 420 mb. at the propeller tip. These excessive pressure reductions are almost instantaneously absorbed into the bigger general eddy that sustains the aircraft and in which the average pressure reduction is of the order of 10 mb. This average decrease is also relatively transitory, since the pressure quickly returns to its normal value after the passage of the airplane. When the initial humidity is very high, however, evaporation of the droplets may proceed slowly enough for a short trail to be formed. These trails are generally associated with the areas of maximum pressure decrease—i.e., the tips of the wings and propellers.

Aerodynamic trails are relatively rare in occurrence and of short duration. They occur at levels where the atmosphere is near saturation. If trails do form, a small change of altitude will usually eliminate them. Because of their infrequency and transitory nature, aerodynamic trails are not considered an operational hazard.

(3) Engine Exhaust Trails

The second type of condensation trail arises when the exhaust gas from an airplane engine mixes with and saturates the environment through which it is passing. The fuel used in airplanes—both conventional and jet—is a hydrocarbon, which upon combustion results in the addition of water vapor and heat to the wake of the aircraft. The added moisture tends to raise the relative humidity of the affected environment, while the added heat tends to lower it. The resulting relative humidity in the trail (f') is dependent upon the amount of heat (H) and water (W) added by the exhaust, the ratio of entrained environment to exhaust gas (N), and the initial pressure (P), temperature (T), and relative humidity (f) of the environment. The critical value of N for the formation of a saturated trail (N_s) is therefore a function of H, W, P, T, and f. In this study all relative humidities are taken with respect to a plane water surface.

For each gram of fuel burned, there are produced approximately 1.4 Gm. of water and 10,000 calories of heat. These values are relatively constant, regardless of the fuel used. In the case of jet aircraft, nearly all of the heat and moisture are injected into the trail, and the present report is based on this assumption. For conventional aircraft, on the other hand, although all the water produced is added to the trail, a significant portion of the heat is dissipated outside of the trail in the form of heat losses from the radiator and mechanical losses from the propeller. The exact amount lost in this manner varies with the type of aircraft;

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it is generally assumed to run from 20 to 40 per cent. Such external heat losses result in higher relative humidities in the trail and increase the probability of contrail formation. A separate study would be necessary for each significantly different type of conventional aircraft.

The amount of air entrained into the exhaust trail varies continuously from zero immediately behind the aircraft to infinity far behind it. The rate at which the air is entrained, however, varies with the type of aircraft, its control settings, and the density and stability of the surrounding atmosphere. An airplane flying at its most efficient speed and altitude will burn less fuel per mile of flight. Consequently, the environment/exhaust ratio in the trail will be correspondingly large at a given point behind the aircraft.

Since the amount of heat and moisture added to the trail per gram of fuel burned is constant, N_s becomes a function of P, T, and f. Since only meteorological parameters of the environment are involved, this relationship is applicable to all jet aircraft. Curves were plotted of N_s as a function of the temperature and relative humidity for each 100 mb. level from 1,000 to 100 mb. Fig. 1 shows the graphs for the 200 mb. level. It is seen that except for the case of an initially saturated environment these curves are double-valued. This means that for a given pressure and temperature, a trail will not form until a certain value of N is reached; with continued entrainment, it will dissipate at another value of N. For example, if the relative humidity is 60 per cent, the temperature is $-55°$C., and the aircraft is flying at 200 mb., a saturated trail will form at a point behind the aircraft where the ratio of the entrained environment to the exhaust gas is 250:1. Subsaturation will result when continued entrainment brings the value of N to 1,500:1. The warmest temperature at which a contrail can form at 200 mb. and 60 per cent relative humidity is $-52.5°$C.

In a similar fashion, the maximum temperature at which contrails can form were picked off all the curves and plotted as a function of pressure and relative humidity. Fig. 2 shows the graphs used in making the actual forecast. The pressure and temperature for the point in question are entered on this graph, and the relative humidity necessary for the formation of a contrail is found. If the point entered lies to the right of the 100 per cent line, it is extremely unlikely that trails will form, since the atmosphere is rarely supersaturated with respect to water. If the point lies to the left of the 0 per cent line, contrails will form even in absolutely dry air. At any in-between point, the formation of trails depends on whether the actual relative humidity of the environment is greater than the required value as given by the graph.

It should be realized that humidity measurements as obtained by radiosondes at low temperatures are inaccurate, but the fact cannot be ignored that the relative humidity is important in determining whether trails will form. Improvement in our instruments will

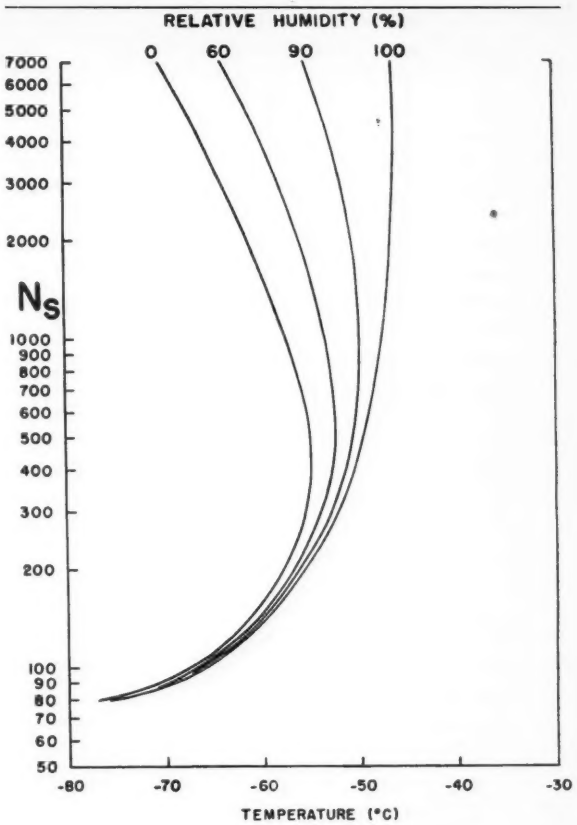

FIG. 1. N_s AT 200 MB AS A FUNCTION OF THE TEMPERATURE AND RELATIVE HUMIDITY OF THE ENVIRONMENT.

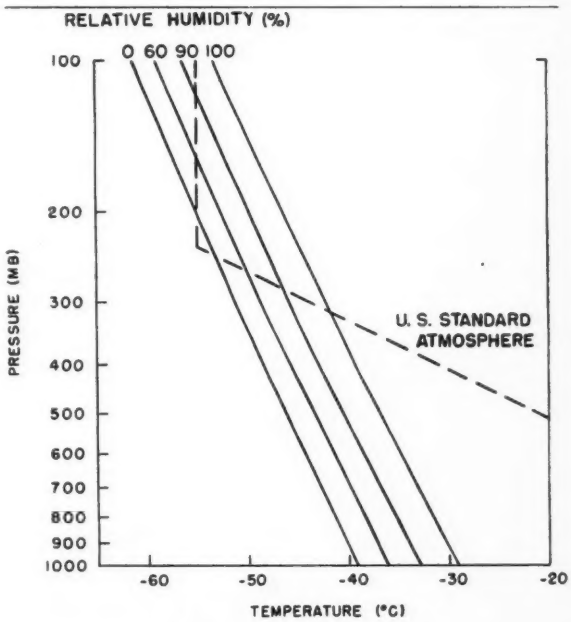

FIG. 2. A GRAPH OF THE REQUIRED RELATIVE HUMIDITY FOR CONTRAIL FORMATION AS A FUNCTION OF THE PRESSURE AND TEMPERATURE OF THE ENVIRONMENT

gradually increase the accuracy of our high-level humidity measurements. In the absence of data, the relative humidity with respect to water in the upper troposphere can generally be assumed to be in the vicinity of 40 to 90 per cent, and in the stratosphere between 0 and 60 per cent. As shown in the graph, this will result in an error of only 3 or 4° in the critical temperature. Indirect methods, such as noting the source of the upper-air flow and the presence or absence of cirrus clouds, can be used to refine the above estimates. The length and persistence of the trail will depend upon the difference between the actual and required relative humidities.

Three basic assumptions have been made in calculating the curves for contrail forecasting: (1) Contrails are composed of ice crystals. (2) Water vapor cannot be transformed into ice without first passing through the liquid phase, thus necessitating saturation with respect to water before any ice can form. (3) A minimum water concentration in ice-crystal form of 0.01 gm/m^3 is required for a distinctly visible trail. Of these assumptions, the first is borne out both by actual photographs of ice crystals in contrails and by halos frequently observed through them. The second has been verified in cloud-chamber tests. The minimum ice-crystal concentration that will produce a visible trail is still open to question, however, since no direct measurements have yet been made. Estimated values begin as low as 0.002 gm/m^3.

The graphs in this paper are therefore based on the formation of a trail saturated with respect to water. Since the critical temperature for contrail formation is in all cases colder than − 29°C., and for high altitudes and low humidities much colder than this, the highly supercooled water droplets will immediately freeze. Freezing nuclei, if not already available at flight level, will be plentifully supplied by the exhaust itself.

As soon as the transformation of the liquid to solid water begins, the trail, which has been at approximately 100 per cent relative humidity with respect to water, will be highly supersaturated with respect to ice. The excess water vapor will immediately begin to sublime onto the ice particles, resulting in the production of larger and larger crystals until the relative humidity in the trail falls to 100 per cent with respect to ice. The resulting ice-crystal concentration in all cases proved more than enough to furnish the 0.01 gm/m^3 specified for a distinct trail. The graphs presented in this paper therefore fulfill all the requirements for the formation of visible trails—i.e., they provide for initial saturation of the trail with respect to water and, after the droplets have changed into ice, the formation of a sufficient concentration of ice crystals to make the trail visible.

(4) Summary

This study has been made to explain the nature of condensation trails, to show their operational importance, and to provide a method of forecasting their occurrence. Aerodynamic trails are formed only in very moist layers, usually under 20,000 ft. They are relatively rare and of short duration and are not considered important from an operational point of view. Exhaust trails, on the other hand, occur only with very cold temperatures and can form even with zero relative humidity. They are frequently persistent, occasionally stretching across the entire sky and lasting for an hour or more. They are considered important from an operational point of view. A complete theoretical treatment of the subject of exhaust condensation trails will appear in a forthcoming issue of the Bulletin of the American Meteorological Society.

Special Notice

Preparations are being made by the I.A.S. for the Twenty-First Annual Meeting, to be held in New York City, January 26–30, 1953. Technical Sessions on all subjects related to aeronautics are being planned.

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Helicopter Transmissions—*Weight vs. Cost*

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ABSTRACT

The conclusion of this study is that helicopter transmissions, while apparently far too expensive, require expensive arrangements, materials, and processes in order to achieve lightness. In fact, further refinement to save weight seems practical, even though first costs would increase. Many transmissions require quality common to automobile transmissions and aircraft engines. The problem consists of two parts: (1) How much is 1 lb. of helicopter empty weight worth? (2) How much does it cost to save that pound?

(1) The worth of 1 lb. is determined by the revenue that 1 lb. of pay-load capacity brings in during the normal life span of the helicopter. Facts drawn from current operations are used to support the revenue and cost figures.

(2) The cost involved in saving weight is attacked in two ways —along the lines of arrangement and refinement. The logical transmission arrangements for a popular-sized helicopter in the 200-hp. class are investigated for their effects on weight and estimated production cost. On the assumption that less fussy tolerances reduce allowable loadings, the decreased cost of cheaper materials and processes is compared to the increased size and weight of one typical arrangement.

INTRODUCTION

HIGHLY INCREASED DEMAND for helicopter development and production has focused attention on the problem of making the transmission. The components, from the point of view of the air-frame manufacturer, are practically impossible to make. Also, they present severe difficulties to the medium-precision semimodern machine shop; tenths of thousandths and fine heat-treat control do not mix with the normal product. Helicopter transmissions belong to the same class as aircraft engines and automotive transmissions. In fact, they require identical materials, processes, and tolerances.[1] The principal reasons why they have received attention from only a few of the manufacturers competent in this field and why they have not become cheaper are that development has been insufficient, quantities involved are too small, and continued business prospects have been much too unsteady. Regardless of the deterrents, the manufacturing requirements remain the same; the helicopter transmission is a piece of high-quality machinery.

Why does it have to be so good? First, its primary function is to convert large amounts of pulsating power from low torque at high r.p.m. to high torque at low r.p.m. without spilling any in the process. Next, it must transmit the power to the rotors, generally going around corners. Engine clutching, free-wheeling, braking, and accessory drives must be provided. Dependability over a temperature range of 295° is of highest consideration. Easy maintenance and overhaul are essential; anything complicated is bound to require frequent attention and tear-down inspection. Field experience dictates roughly 500 hours between major overhauls.[2] Lightness is paramount, more so than in other aircraft. When all conditions have been met, the measure of success is weight and cost. The problem then breaks down into two parts: How much is 1 lb. of helicopter empty worth; how much does it cost to save that pound?

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WORTH OF WEIGHT

The only pragmatic gage of the worth of weight is the revenue that 1 lb. of pay-load capacity brings in over the normal life of the vehicle for the particular operation in question. Revenue is the same as cost of operation plus profit. For uses such as military activities, police patrol, rescue work, and executive travel, revenue and profit become obscure. The cost alone represents a measure of the utility of the pay load. To substantiate current helicopter charging rates and to give a clear understanding of the elements in operating cost, Table 1 is presented. These items are averages drawn from all kinds of existing, difficult helicopter operations, including military, using typical small helicopters. The basic assumptions are:

(a) Time of depreciation to 10 per cent residual value is 4 years, the legal minimum.

(b) Rate of utilization is 750 hours per year or a total of 3,000 hours (major parts of high-performance aircraft engines are expected to last about 6,000 hours, but the engine does not obsolesce so fast).

(c) Expendability is a loss of 55 per cent of first cost every 3,000 hours, roughly equivalent to 25 per cent premium hull insurance at above depreciation.

(d) Approximate price is $28,000.

(e) Five hundred lb. pay load.

TABLE 1

Item	Cost per Hour	Per Cent of Total
Depreciation	$ 8.40	12
Interest on investment (5 per cent)	1.00	1
Expendability or insurance	5.10	7
Parts	5.00	7
Subtotal of manufacturer controlled cost	$19.50	27
Direct operating, personnel, and administrative expense	50.70	73
Total cost plus profit = income	$70.20	100

The earning capacity of each pound of pay load if the helicopter operates fully loaded all the time follows readily, but in most operations the successful use of the aircraft does not depend upon the pay load all the time. A common assumption is that the pay load capacity is of importance only 50 per cent of the time. This is not to be confused with load factor. Even though an aircraft is not always fully loaded, each pound of pay load contributes the necessary potential if the aircraft must operate on a scheduled run of specified capacity. The earning capacity of each pound of pay load for the life of the helicopter is expressed as

$$\frac{(\text{total hours}) \times (\text{income per hour}) \times (\text{pay load importance factor})}{(\text{total pay load capacity})}$$

$$\frac{3{,}000 \times \$70 \times 50\%}{500 \text{ lbs.}} = \$210 \text{ per lb.}$$

While 1 lb. of pay load is worth $210 to the operator, it does not follow that the manufacturer should spend the full amount per ship to save a pound. Every extra dollar that the manufacturer spends is reflected not only in the first cost or depreciation but also in the interest, insurance, and parts costs as shown in the table. These total $19.50, whereas the first cost is only $8.40. Therefore, every dollar the manufacturer spends increases the operator's cost $2.25. Accordingly, the manufacturer must not spend more than

$$\$210 \text{ per lb.}/\$2.25 = \$93 \text{ per lb. per helicopter}$$

to save weight if he is to help the operator come out even. If the operator is to *benefit* by the manufacturer's effort and look forward to some economic advantage to compensate for the risk involved in any change, the cost to him should probably be not more than $50 per lb. Of course not every pound saved or added is worth the same as every other pound. If increase in pay load of 100 lbs. resulted in a four-place helicopter that could secure a large market, when perhaps a three-place machine could not, the worth might be several times $9,300. On the other hand, few customers would pay $930 extra for the privilege of carrying along another $1^1/_2$ gal. of fuel. (It might be appropriate here to expose the fallacy of determining the value of weight by dividing initial cost by pay load. Such a method implies that the pilot, fuel, mechanics, sales department, and equipment are standing idly by already paid for and that the only expense consists of one new helicopter. Further, it implies that the helicopter will be used just once.)

The effects of size of helicopter, type of operation, frequency of use, and all the other variables are extremely important. In general, the more difficult the job, the higher the worth of useful weight For instance extra instrumentation or twin-engined installations will increase the cost of helicopter passenger service compared to crop-dusting work. The increase in first cost and operating costs of special duty military helicopters dictates a highly multiplied value of weight.

Therefore, the $93 per lb. quoted previously represents a minimum value for modern helicopters.

Cost of Reducing Weight

The problem of how to skimp a pound in transmissions can be attacked in two ways—along the lines of refinement and arrangement.

Refinement involves examination of the details: Should we use the best materials and fanciest processes, with the lengthiest development tests, in an attempt to get as light and expensive a unit as possible, or should we use cruder methods and arrive at a heavier gearbox sufficiently cheaper to pay for its weight at the rate of $100 per lb?

Gears being the most important class of components in transmissions, examine the loadings to which the gear teeth are subject. Briefly, there are three types—compressive, bending, and sliding conditions. The first normally determines the size of gears. Modern helicopter transmissions run compressive stresses, or Hertz stresses, from 125,000 to 200,000 lbs. per sq.in., the latter value requiring considerable development work. They are able to achieve successful behavior in this range of loading by virtue of hardness and accuracy. No matter how hard or soft the gears are, they must be reasonably accurate for the speeds and powers encountered in helicopters. If, in an attempt at cheapness, the teeth are made soft instead of carburized or nitrided, the allowable maximum loading slips to 60,000 lbs. per sq.in. or about half of the conservative figure for hard gears. Because the stress varies as the square root of the load, face loadings on soft gears must be less than one-quarter of those used on hard ones. The only way to decrease loadings while maintaining normal proportions is to increase diameters. But weight increases as the cube of the diameter for normal proportions. The result is a transmission of something like five times the weight of the hard-gear variety.

Opening up tolerances on such details as housing bores for bearings, spline tooth straightness, roller bearing guide shoulder squareness, and quill shaft concentricity saves a few dollars but dictates impossible load reductions in order to accommodate the situation in which only part of a component works while the rest is idle. Another result is increased wear due to lack of tightness of mounting or due to increased vibratory loadings. The trend in modern helicopter transmissions has been involuntarily toward tightening tolerances to assure even load distribution, increasing hardness to prevent wear, and using better materials to obtain higher endurance limits.

Changes in arrangement of transmissions have always been an extremely interesting activity for designers and a source of hope for manufacturers. There are almost as many different types of configurations as there are different types of helicopters. Of course, engine and rotor positions help increase the number of varieties. The principal arrangements for the main power train consist of planetary spur, single-mesh spur, and single-mesh bevel. An attempt is made here at a direct comparison between a two-stage planetary system representing the expensive type and a single-mesh spur

design typifying the cheap st type. For the sake of elimination of variables, they have been chosen to be applicable to the same engine and engine position and generally, to the same helicopter. They represent the extremes of arrangement which will meet those requirements. The results of that comparison are summarized in Table 2.

The result of the single-mesh transmission saving only $120 accompanied by a weight increase of 25 lbs. dampens the immediate hope of achieving a significant reduction in helicopter transmission prices. (Results of analysis, by Sikorsky Aircraft Division, United Aircraft Corporation, of several finished transmissions of different arrangements indicate that the cost per pound of the various types remains approximately constant.) Note that, while the main gear cost is cut in half, the case expense triples because of the complexity of the castings, and hugely increased loads on them, and resulting machining and grinding. The case also becomes the most important item of weight. Higher allowable loadings were hypothesized than would be used in the planetary arrangement, because cocking deflections can be reduced and the problem of distribution of load between meshes disappears. If the result is viewed another way, improving the gearbox weight by progressing from the single-mesh to the planetary type saves weight at a cost of only $4.80 per lb. standard, or $7.20 per lb. actual.

TABLE 2

Characteristics	Planetary	Single Mesh
Weight	95 lbs.	120 lbs.
Standard cost (estimated for optimum production run; should be at least 1.5 these figures)	$2,514	$2,394*
Number of gears in main train	16	2
Proportion of total cost	28%	13%
Number of gears in accessory drives	7	7
Proportion of total cost	9%	10%
Number of other difficult internal parts	6	4
Proportion of total cost	14%	10%
Cases—proportion of total cost	12%	36%
Bearings—proportion of total cost	1%	2%
Remaining details—proportion of total cost	19%	15%
Assembly—proportion of total cost	17%	14%

* Estimated only, by comparison to similar parts in the planetary example and other Bell transmissions; same general methods of manufacture have been assumed.

Closing Remarks

In the interest of providing the most economical transmissions, the general arrangement should be the most compact and refinement should be directed toward the lightest possible components. This does not mean that special processes not already developed should be called upon for production parts. It does mean that the more expensive arrangements are worth while and that development should be actively carried on to increase allowable loadings. The most effective manufacturing methods must be used in order to aid such development. Automotive industry demands spurred the use of antifriction bearings, spiral bevel gears, and high-octane fuels. Without the prior costly development of those products, the helicopter would not have been feasible. Similarly, without today's efforts toward improved refined designs, tomorrow's more practical helicopter of wider use would not be possible. The important principle is that, while a light efficient transmission costs more, it does more work per dollar invested than a heavy cheap one.

If mobilization plans should call for immediate decupling of helicopter output, it may be that the apparent lack of production capacity would boost transmission prices high enough to justify an economical switch to cruder units. But the greater likelihood is that the prospect of large volume at favorable prices, or some other inducement, would attract enough manufacturers who are today capable of handling this type of work.

References

[1] Geschelin, Joseph, *Fewer Aluminum Parts in Ford Automatic Transmission*, Automotive Industries, p. 46, October 1, 1951.

[2] General Engine Bulletin No. 141, Bureau of Aeronautics, Department of the Navy, January 8, 1952.

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Electronic Controls as Applied to Aircraft Inverters

B. M. STARR*
Eicor, Inc.

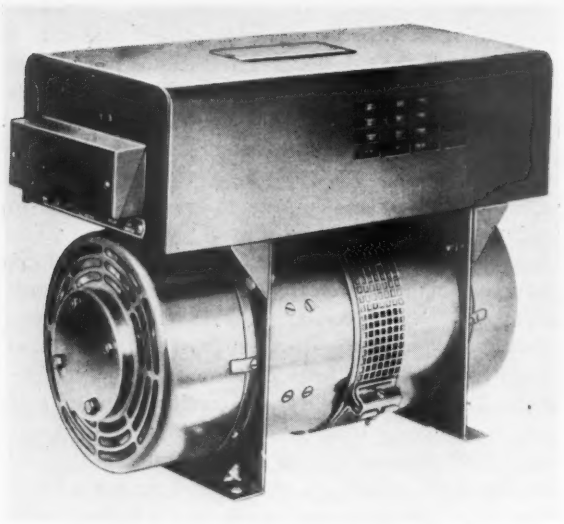


FIG. 1. Eicor inverter model 1-2500A-115-S-2A.

INTRODUCTION

TODAY WE ARE IN A PERIOD to which future historians might refer as the Age of Electronics. Although great strides have been made in this field, the science is still in its infancy. There is an infinite number of uses to which electronics can be applied, and it remains only a question of time as to when all of the commercial possibilities will be explored. At the present time, most of the electronic research at Eicor has been diverted to the defense effort.

Eicor's major contribution has been in the field of electronic controls as applied to aircraft alternators. During World War II, the company made thousands of small dynamotors, inverters, and motors for the armed services. It was therefore natural for this company to undertake the development and manufacturing of controls for rotary equipment. (See Fig. 1.)

Up until the end of 1947, standard controls for inverters had been electromechanical regulators. However, these regulators were never completely satisfactory. Difficulties were constantly encountered in the regulation and maintenance of this type of equipment. Because these regulators are electromechanical devices, there are moving parts to wear out. The carbon piles and contacts cause no end of difficulty due to the dust, dirt, and other contamination which collect between pieces of carbon in the carbon pile and contacts. It was therefore decided from the beginning that any control designed and developed for rotary equipment should be of a type other than the conventional electromechanical device.

Any control for close regulation of power-converting equipment must have such characteristics as fast response, low maintenance, good stability, freedom from spurious modulation due to shock and vibration, and, in general, definite dependability. The use of vacuum tubes was the logical answer to all of these desirable characteristics, with the possible exception of dependability and efficiency. Because of the heater required in vacuum tubes, their efficiency and dependability may be low. Because of their extremely fast response time, hard vacuum tubes would be the ideal type of tube, assuming, of course, that a dependable tube could be purchased or developed for this purpose. Neither a vacuum tube nor a company interested in developing a vacuum tube that would have the necessary small size and power-handling capabilities could be found.

The only remaining choice of an electronic tube was that of a gaseous grid-controlled rectifier. In spite of the faults this tube may have, it has definite advantages, such as a high efficiency and great power-handling capabilities in a small-sized envelope. Disadvantages, such as special control circuits to operate this tube and a high noise level, were not sufficient to prevent the development of the controls in use today.

INVERTER CONTROLS

The first step, of course, was the development of voltage- and frequency-sensing networks to sense the output voltage and frequency of the inverter and, in some way, to control the thyratrons that supplied the d.c. power to their respective fields. The voltage-sensing network is a comparatively simple bridge circuit (see section on voltage control). For the frequency-sensing network, we investigated various means of sensing the frequency, such as tuned circuits, and we were able to develop a simple high-pass filter that gave us an excellent slope of approximately 1 volt per cycle change at 400 cycles per sec. for detecting frequency. The change of voltage input to the filter causes a change of 0.09 volt in the output per 1.0 volt change of input. This slight voltage sensitivity is not detrimental to the operation of this frequency-sensing filter because any reduction in output voltage of the inverter is usually due

*Chief Electronic Engineer.

to those factors that also tend to reduce the revolutions per minute of the motor, such as reduced input voltages or increased load. Therefore, this slight sensitivity to voltage change improves the response of the frequency-sensing network. Because this control is so unique, a diagram is included to assist in the explanation of its operation (see Fig. 2).

The d.c. supply source for the frequency control field is a full-wave grid-controlled gaseous rectifier circuit employing two 2D21-type rectifiers. The grid and plate voltage of the thyratrons are out of phase by approximately 90°. This phase shifting is accomplished by physically winding the transformer windings that supply the anodes of the thyratrons in quadrature to the output winding of the alternator. Since this unit employs a rotating field, the output winding and the transformer windings are parts of the stator. The output of the alternator supplies the primary of the grid transformers. Control of the thyratron is accomplished by varying to d.c. bias between control grid and cathode. The means of controlling this d.c. bias is a 6AT6 hard vacuum tube employed as a variable resistor. As frequency increases, the output of the high-pass filter will also increase. This voltage is rectified by a bridge rectifier and filtered slightly by the load of the rectifiers and a 0.015-mf. capacitor. The positive end of the

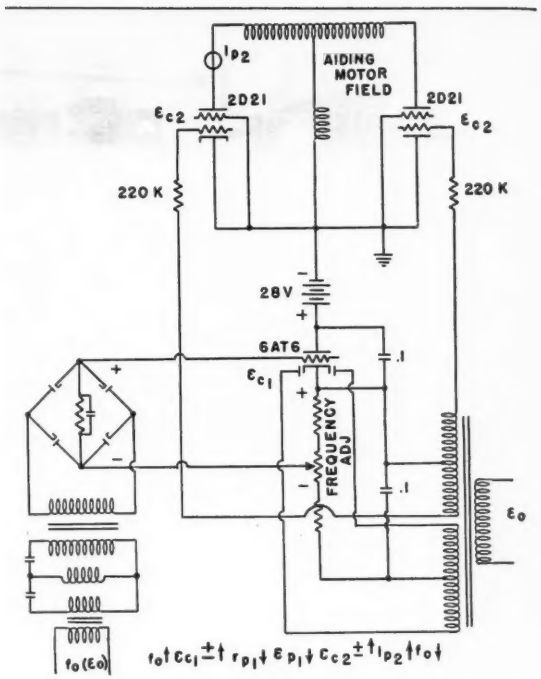
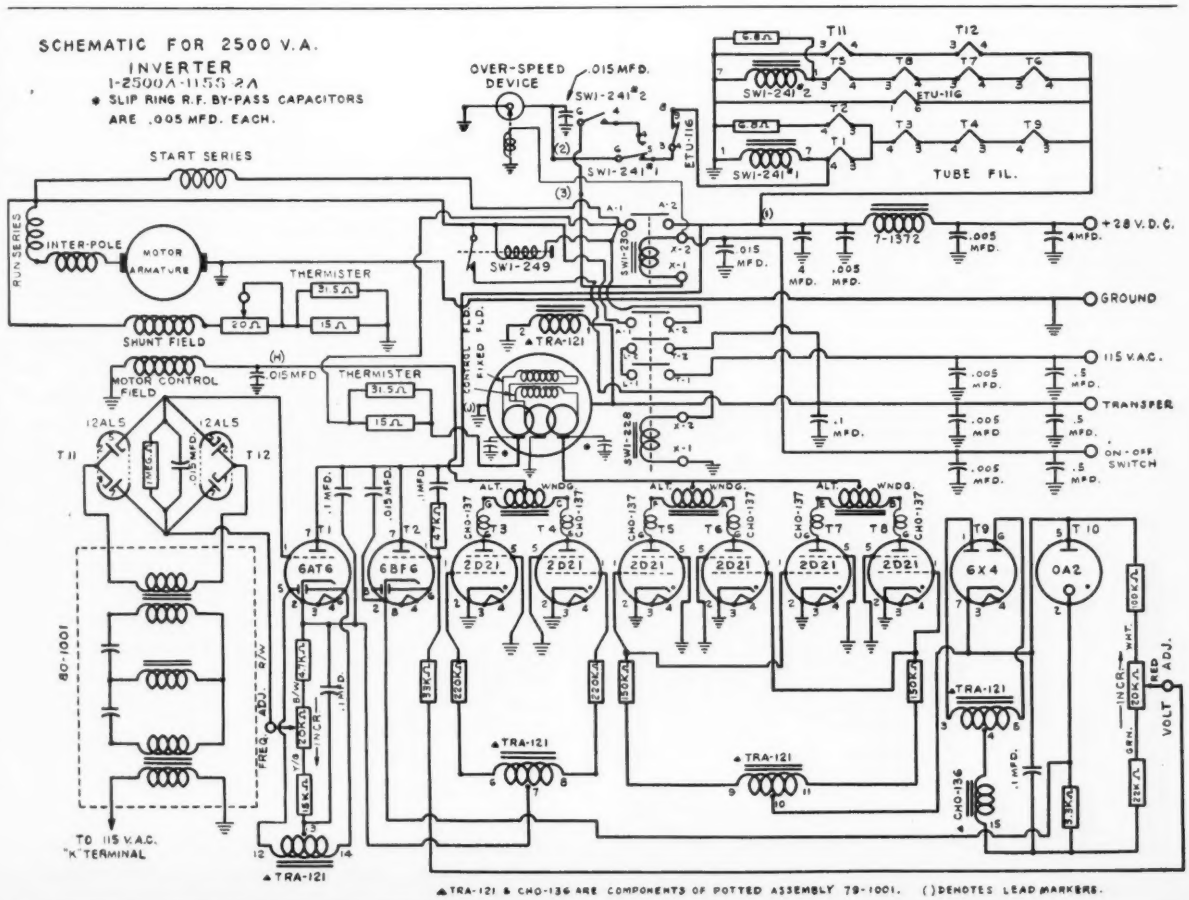


FIG. 2. Two thousand five hundred va. inverter alternator output frequency control circuit.



The author in a section of the electronics laboratory at Eicor, Inc.

Taking radio noise measurements in a copper-shielded room made especially for this test.

One of the engineers at Eicor conducting simulated flight condition tests over a wide range of temperatures and pressures.

bridge rectifier is connected to the grid of the 6AT6 tube. The negative end of the bridge rectifier is connected to a potentiometer in the full-wave rectifier circuit, employing the duo-diodes of the 6AT6 tube. This full-wave rectifier provides a voltage that may be considered as constant for our purpose of analysis. The two voltages are connected in such a manner as to oppose each other, the positive end of the bridge rectifier being applied to the grid of the 6AT6 tube and the positive end of the full-wave rectifier being connected to the cathode. The voltage between grid and cathode, therefore, is equal to the difference of the two voltages, one being a constant voltage and the other voltage varying with frequency. This enables us to have a greater change of grid voltage in the region of the low voltage necessary to control this tube than we could otherwise obtain with this frequency-sensing circuit.

This circuit is unique in the respect that the plate resistance of the 6AT6 tube is employed as the variable resistance and controlling component in the d.c. bias circuit of the 2D21 thyratrons. The grids of the thryatrons are connected to an a.c. voltage in such a way that it may be compared to a full-wave rectifier. By neglecting a large number of variables, we can consider this grid circuit of the thyratrons as being a constant-current full-wave rectifier. The load of this rectifier consists of the 220,000-ohm grid resistor, the 28-volt battery, and the plate resistance of the 6AT6 control tube. The voltage developed across the 220,000-ohm resistor in the grids of the thyratron may be considered constant if the current is considered constant also. The voltage developed across the 6AT6 plate resistance will vary as the plate resistance of the tube varies. This voltage developed across the plate resistance of the 6AT6 tube is of opposite polarity to that of the 28-volt battery. The d.c. voltage developed across this combination will therefore be the difference. This varying d.c. bias is the controlling voltage of the thyratron anode currents.

To follow the sequence of control to completion, assume an increase in the output frequency, the output voltage remaining constant. As the output frequency increases, the output voltage of the high-pass frequency-sensing circuit will also increase. The bridge rectifier will rectify this voltage, and the change of d.c. voltage will appear between grid and cathode of the 6AT6 as grid control voltage, which is becoming more positive. Thus, as the plate resistance of the 6AT6 tube decreases, the voltage across this plate resistance will also decrease. The difference between the 28-volt battery voltage and the drop across the plate resistance of this tube will be applied to the grid and cathodes of the 2D21 thyratron. The grid bias of the thyratrons will become more positive as a result of the decreasing voltage drop of the plate resistance of the 6AT6 tube.

As the thyratron grid voltage becomes more positive, the anode currents of the thyratrons will increase. This increase in current, which flows through the motor control field, will cause the frequency to decrease, thus completing the cycle and correcting the change in out-

put frequency. The 0.1-mf. capacitor across the plate resistance of the 6AT6 control tube will reduce the effect of this varying resistance upon the applied a.c. voltage in the grid circuit of the thyratrons. The 28-volt battery represents the airplane d.c. source and serves two purposes in this circuit. First, by bucking two voltages against one another in this fashion, it is possible to obtain a greater change in grid bias than would otherwise be possible in the range of grid bias required for control of the thyratron.

For example, assume that a negative grid bias of 1 to 3 volts is required by the 2D21 for complete control. Further, assume that the control method is capable of causing a voltage change from 25 to 31 volts which is available to control the thyratrons. A bias of 25 volts is much too great to allow conduction of current through the thyratrons. Through the use of a voltage divider, however, we can reduce this to the required 1 volt or 1/25 of the available control voltage. The maximum grid bias then available would be 1/25 of 31 or 1.24 volts. This arrangement would only give a grid bias range of 1 volt to 1.24 volts, and complete control would be impossible. However, if this control voltage available (25 to 31 volts) is bucked against 28 volts d.c., the grid bias then would be the difference of the two voltages of $+28 - 25$ or $+3$ volts, and $+28 - 31$ or -3 volts. This gives a grid bias range of ± 3 volts and is more than sufficient to control completely the thyratron.

The other function of the 28-volt battery source is to help correct the change in output frequency which is caused by the variation of this 28-volt source that is the power supply for the inverter input. For example, if the 28-volt source is reduced for any reason to a lower voltage (assume a value of 26 volts), the output frequency of the inverter will also be reduced because of the reduction of the motor speed. To correct this drop in frequency, the grid bias of the 2D21 thyratrons must become more negative in order to reduce the motor control field current which will allow the motor speed to increase. Because of the manner in which the 28-volt battery is used in the grid bias circuit of the thyratrons, any reduction of the battery voltage will cause the grid bias to become less positive or more negative. This increase in negative grid bias will cause the motor control current to be reduced and, in turn, will cause the motor speed or frequency to increase. (See Fig. 3.)

Alternator Output Voltage Control

The voltage control circuit of the inverter that controls the a.c. voltage output operates in a similar manner, with the one exception that the sensing circuit is sensitive to changes of output voltage but is not sensitive to changes of output frequency in the voltage control circuit.

The voltage-sensing bridge circuit consists of a rectifier to provide the d.c. voltage for the bridge, the OA2, and the four resistors. Assume that the OA2 is a perfect voltage regulator. Also assume that at this instant the inverter output voltage (ϵ_0) is increasing. This increased voltage will appear across the bridge circuit as an increase in the d.c. voltage, which is $\epsilon_1 + \epsilon_2$. The amount of increase in the d.c. bridge voltage will depend upon such things as the turns ratio of the transformer in the rectifier circuit and the increased loss due to this increased voltage. Let

$$K = \Delta\epsilon_{d.c.}/\Delta\epsilon_0$$

For this circuit K is equal to 9/6 or 1.5.

Inverter undergoes the final production line testing prior to shipping.

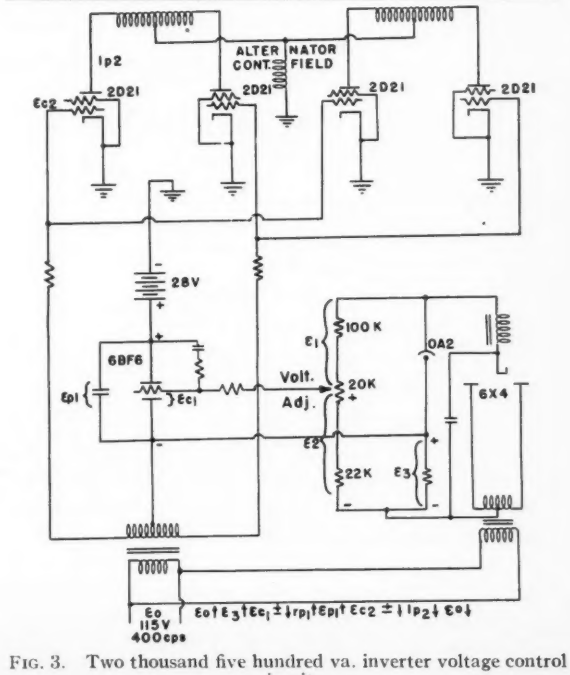
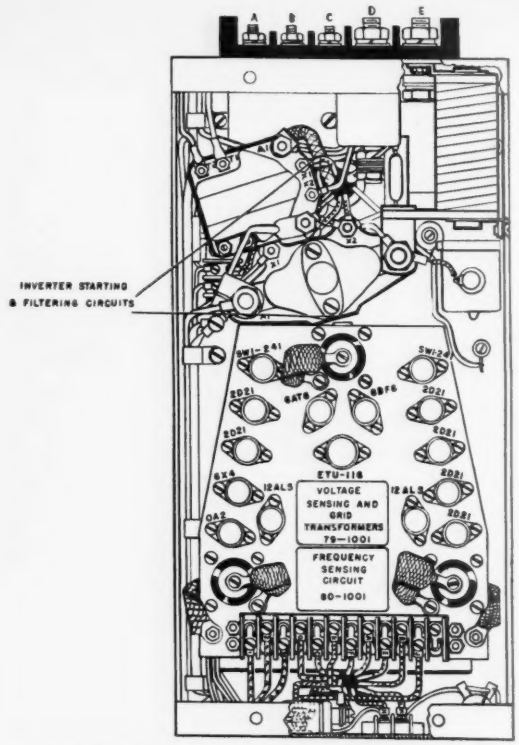


Fig. 3. Two thousand five hundred va. inverter voltage control circuit.



Eicor inverter model 1-2500A-115-S-2A. Top view.

The grid bias of the 6BF6 is equal to the difference of ϵ_2 and ϵ_3. Since the OA2 is assumed perfect, the voltage change of ϵ_3 will be equal to $\Delta\epsilon_{d.c.}$. Therefore,

$$\Delta\epsilon_3 = \Delta\epsilon_0 K$$

Ideally, ϵ_2 should remain constant; however, in this circuit ϵ_2 does vary. Assume that the 20,000-ohm potentiometer used for adjusting the output voltage of the inverter (ϵ_0) is set at its medium point. ϵ_2 changes by the ratio of 32,000/142,000, or

$$\Delta\epsilon_2 = \Delta\epsilon_{d.c.}\ (32/14)$$
$$\Delta\epsilon_2 = 0.225\epsilon_0 K$$

The grid bias of the 6BF6 (ϵ_{c_1}) is equal to the difference between ϵ_2 and ϵ_3. Therefore,

$$\Delta\epsilon_{c_1} = \Delta\epsilon_3 - \Delta\epsilon_2$$
$$\Delta\epsilon_{c_1} = \Delta\epsilon_0 K - 0.225\Delta\ \epsilon_0 K$$
$$\Delta\epsilon_{c_1} = \Delta\epsilon_0 K(1-0.225)$$
$$\Delta\epsilon_{c_1} = 0.775\Delta\epsilon_0(1.5)$$
$$\Delta\epsilon_{c_1} = 1.16\Delta\epsilon_0$$

Thus for every volt change of the output voltage (ϵ_0), the grid bias (ϵ_{c_1}) of the 6BF6 changes 1.16 volts. The 6BF6 is employed in the same manner as the 6AT6 in the motor control circuit—to control the alternator side of the inverter. Assume an increase in the alternator output voltage (ϵ_0). ϵ_3 will also increase, and, since ϵ_2 is nearly constant, the grid bias of the 6BF6 (ϵ_{c_1}) will become more negative. This will cause an increase in the plate resistance of the 6BF6 (r_p). Again assuming the 6BF6 cathode current to be constant, the plate voltage (ϵ_{p_1}) will also increase. This increase in plate voltage, which is opposing the 28-volt battery voltage, causes the grid bias of the 2D21 thyratrons (ϵ_{c_4}) to become more negative, thus reducing the alternator control field current (I_p) and alternator output voltage (ϵ_0). The control cycle is completed and the output voltage change is corrected.

Because of the power requirements, two sets of full-wave thyratron circuits are employed. By employing separate transformer windings for each full-wave rectifier circuit, we are able to achieve a degree of isolation of these two circuits that feed a common load. Also by

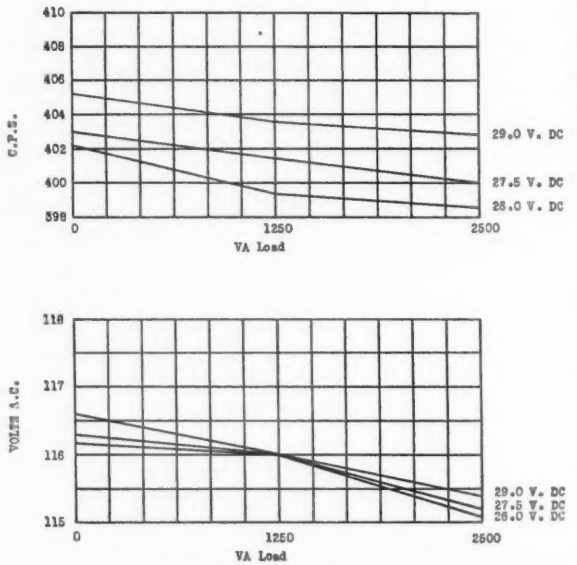


FIG. 4. Inverter, Eicor, 1-2500A-115-S-2A SN-PP-1-2,500 va.-single phase; voltage and frequency regulation; sea level, room temperature; 26.0, 27.5, 29.0 volts d.c. input; loads shocked; readings at 0, 1,250, and 2,500 va. load.

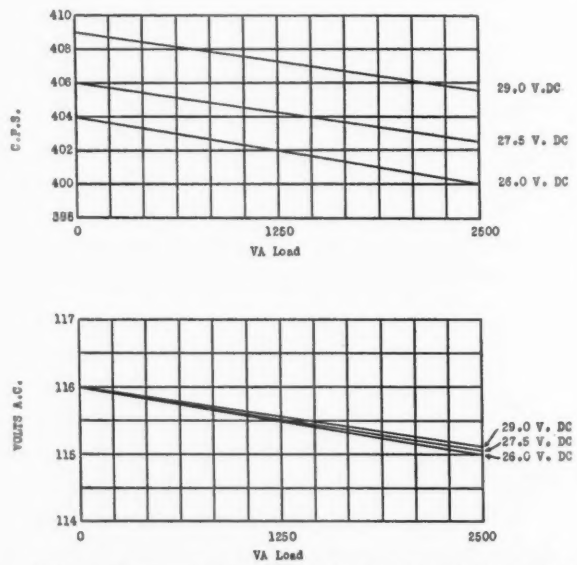


FIG. 5. Inverter, Eicor, 1-2500A-115-S-2A SN-PP-1-2,500 va.-single phase; voltage and frequency regulation; sea level, +71°C.; 26.0, 27.5, 29.0 volts d.c. input; loads shocked; readings at 0, 1,250, and 2,500 va. load.

using a common grid resistor for the in-phase thyratrons, a satisfactory degree of balance of anode currents is achieved.

Use of these circuits to control the voltage and frequency of inverters has resulted in a frequency regulation of 10 cycles or less, an output voltage regulation of 3 volts or less, with a change of input voltage between 26 and 29 volts, and with a change of output from no-load to full-load. Ambient temperature effect is slight at +71°C. and has no effect at −55°. (See Figs. 4, 5, and 6.)

Conclusion

The engineers at Eicor are continuing to improve both inverters and controls for inverters. They are constantly striving to reduce the size and complexity of these controls and to improve the regulation of these controls. We are confident that the achievements of the last decade are few when compared to future progress that will be made through continued hard work and imaginative planning in the field of applied electronics.

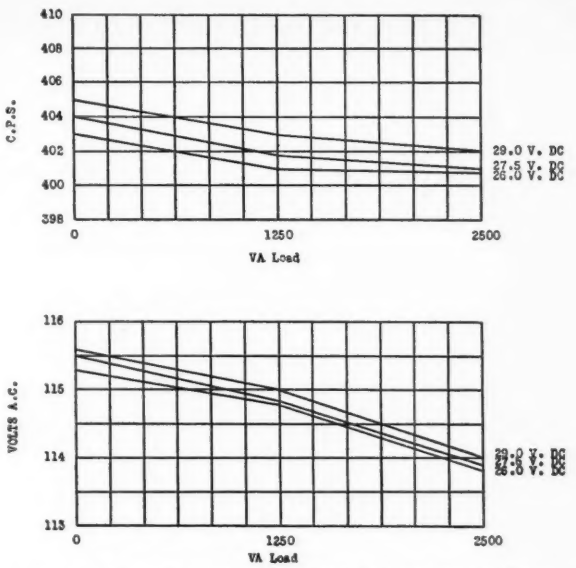


Fig. 6. Inverter, Eicor, 1-2500A-115-S-2A SN-PP-1-2,500 va.-single phase; voltage and frequency regulation; sea level, −55°C.; 26.0, 27.5, 29.0 volts d.c. input; loads shocked; readings at 0, 1,250, and 2,500 va. load.

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Temperature-Compensated Springs for Aircraft Application

M. GERARD FANGEMANN*
John Chatillon & Sons

THE USE OF TEMPERATURE-COMPENSATED SPRINGS in industry, especially the aircraft industry, is becoming more apparent daily. One of the latest applications for temperature-compensated springs is the Eclipse-Pioneer fuel-flow system, which indicates the rapidity with which fuel is being consumed by the engine.

This system consists of an Autosyn† transmitter mounted in the fuel supply line to the engine which is directly linked to the pilot's or flight engineer's instrument panel. The rate at which fuel is being consumed is thus indicated and enables the pilot to monitor his fuel consumption continuously and thus obtain economical performance of the engine.

The fuel-flow transmitter is composed basically of a metering mechanism and an Autosyn. A temperature-compensated Iso-Elastic spiral spring located in the metering mechanism provides the accurate calibration factor for the instrument, and its importance can readily be realized. This special nickel alloy, called "Iso-Elastic," is a patented alloy and is produced by John Chatillon & Sons in New York. It is rapidly finding new applications in all force-measuring devices wherever temperature changes occur. The temperature coefficient of the modulus of elasticity, which is the factor governing the change in strength of a material with temperature changes, is approximately one-tenth that of spring steel. There are many other important characteristics, however, that add to the versatility of this special alloy.

Hysteresis or "back error" is an important characteristic of spring applications in instruments. Hysteresis error is usually determined by loading a spring through a cycle beginning at zero load, applying half load and full load, and returning to half load and, finally, to zero load. If this loading is plotted, a hysteresis loop is formed, and the curves do not coincide at any other point but at full and zero loads. The difference at the midway loading condition is designated as the hysteresis error. Ordinary materials have a "back error" of approximately 0.1 to 0.2 per cent of total deflection, whereas Iso-Elastic usually has a maximum hysteresis error of 0.02 per cent.

Another important characteristic is that of drift, which is the additional deflection that continues after a designated load is applied. This additional deflection may continue for minutes, hours, or days, depending upon the material used, the stress at which the spring operates, and the work hardening that takes place. Steel springs ordinarily have a drift error of 0.06 per cent in approximately 24 hours. However, Iso-Elastic will reduce this error to approximately 0.01 per cent in 24 hours.

From the above, the advantages of using Iso-Elastic springs for aircraft applications can readily be seen. In the Eclipse-Pioneer fuel flowmeter, fuel enters the inlet port of the transmitter and is directed against a hinged vane in the metering chamber. The impact of the fuel causes the vane to move against the restraining force of the calibrated Iso-Elastic spiral spring. When the restraining force of the spring balances the force of the fuel, the vane stops moving. This position of the vane represents a measure of the rate at which fuel is passing through the metering chamber. The Autosyn unit electrically transmits the position of the vane in the meter to the pointer of the indicator on the instrument panel and, thus, provides an indication of the rate of fuel consumption.

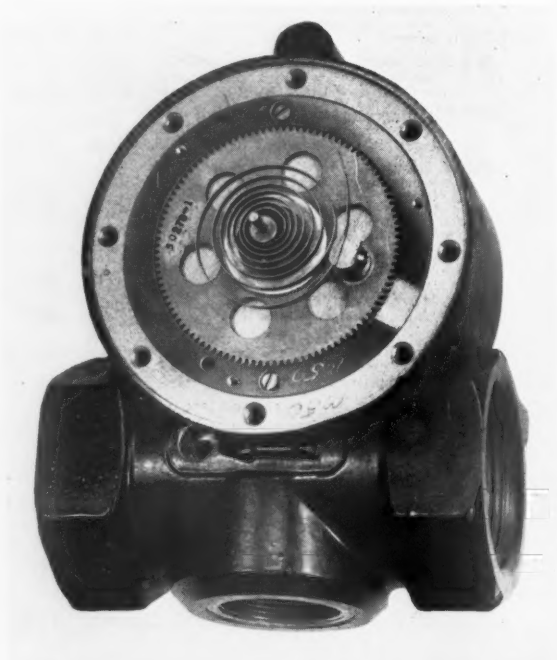

FIG. 1. Illustration shows partial assembly of Bendix fuel flowmeter produced by Eclipse-Pioneer Division in Teterboro, N.J., with the temperature-compensated Iso-Elastic spiral spring.

*Manager, Spring Division.
†Registered trademark of the Bendix Aviation Corp.

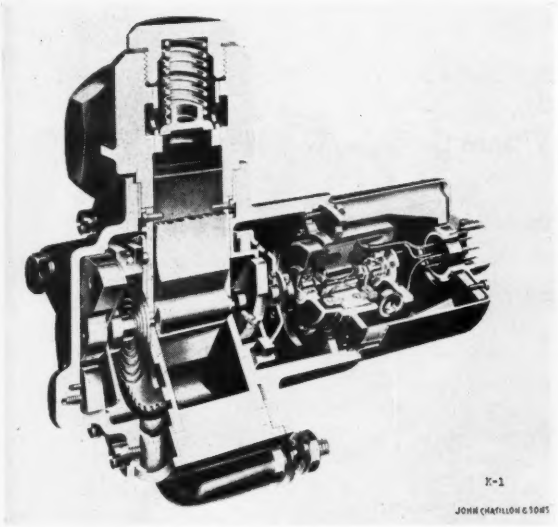

FIG. 2. Illustration showing cutaway section of a complete Bendix fuel flowmeter with an Autosyn transmitter attached.

The original spring used in the fuel-flow transmitter was of beryllium copper. However, in the constant effort to improve the performance of their products, Eclipse-Pioneer engineers have modified the design of the transmitter to make use of an Iso-Elastic spring, which will ensure a spring rate that will not change with changes in temperature. The transmitter is built to specifications requiring specific accuracy tolerances over a temperature range of $-67°$ to $+150°$F. The uniform characteristics of Iso-Elastic have provided excellent performance in meeting this requirement over this entire temperature range without the need for any cumbersome temperature-compensating mechanism.

Listed in the right column are the main physical properties of Iso-Elastic.

FIG. 3. Illustrates the actual calibration of a Chatillon Iso-Elastic spiral spring for use in Bendix aircraft instruments. Hysteresis error is less than 0.02 per cent of deflection, while drift error is less than 0.01 per cent of deflection.

Composition	36% nickel, 8% chromium, 0.5% molybdenum—balance iron and other small constituents
Thermal coefficient of the modulus	-20×10^{-6}/°F. to 15×10^{-6}/°F. (Spring steel is -190×10^{-6}/°F.)
Hysteresis error	Less than 0.05% of deflection
Creep error	not more than 0.02% of deflection in 5 min.
Tensile strength	170,000 lbs. per sq.in.
Young's modulus	26×10^6 lbs. per sq.in.
Torsion modulus	9.2×10^6 lbs. per sq.in.
Practical working stress in bending	90,000–100,000 lbs. per sq.in.
Practical working stress in torsion	40,000–60,000 lbs. per sq.in.
Hardness	Rockwell C30 to C36
Electrical resistance	approximately 528 ohms per mil. ft. (at 20°C.)
Coefficient of linear expansion	$+4 \times 10^{-6}$ approximately

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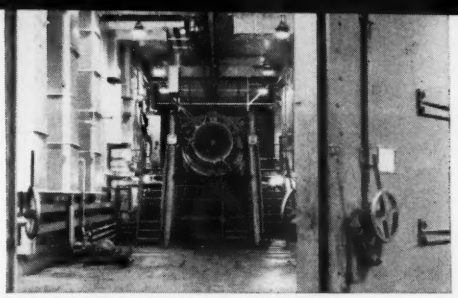

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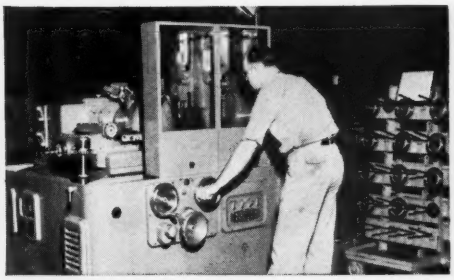

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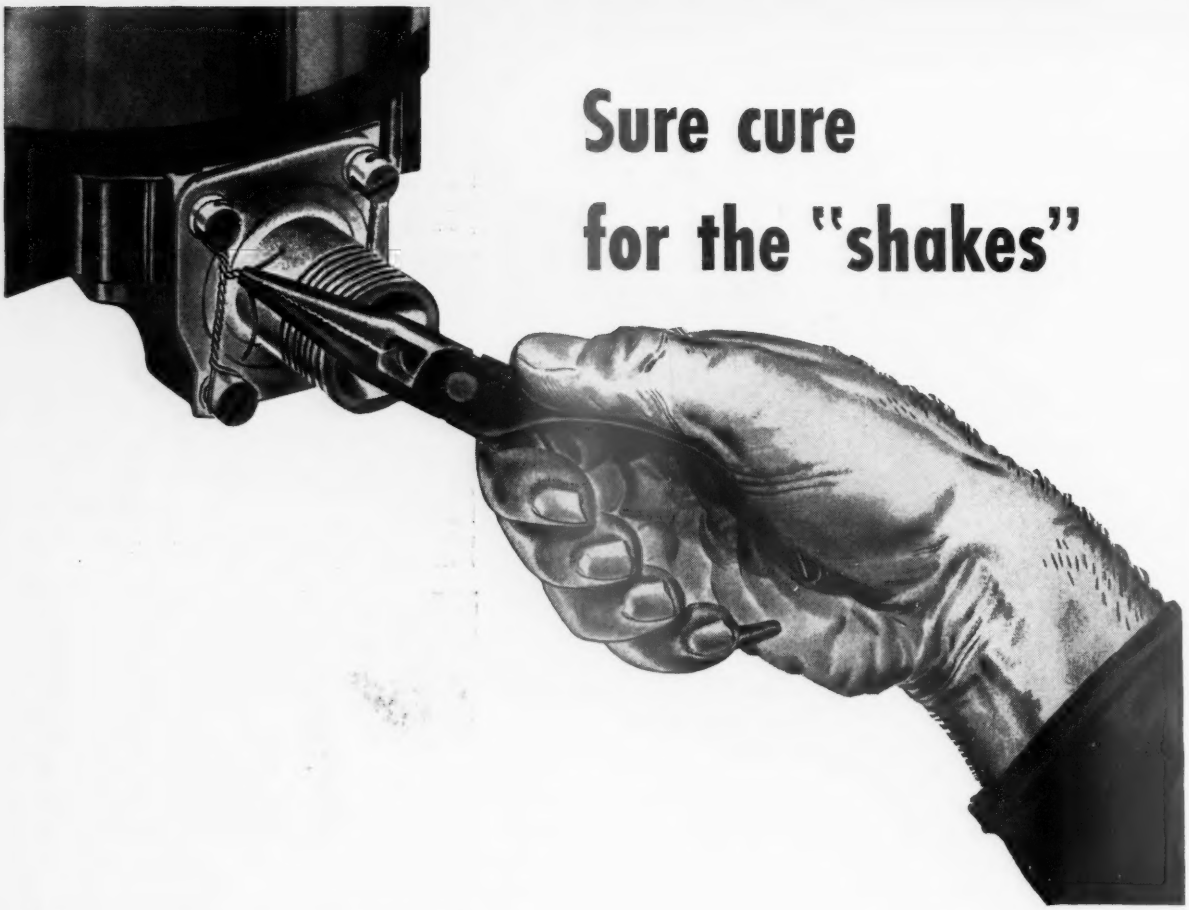

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I.A.S. Previews

Summaries of Current Papers Accepted for I.A.S. Publications

On Heat Transfer over a Sweat-Cooled Surface in Laminar Compressible Flow with a Pressure Gradient

By

Morris Morduchow

Polytechnic Institute of Brooklyn

A simple expression is derived for the normal injection velocity distribution theoretically required to maintain a given uniform temperature along a porous surface in the laminar boundary-layer region of a compressible flow with a given velocity distribution outside of the boundary layer. This expression is valid for any given free-stream Mach Number but is based on a Prandlt Number of unity and on the assumption that the viscosity coefficient varies linearly with the temperature. By using the Dorodnitsyn type of transformation, the variation of fluid properties even in the case of zero Mach Number is taken into account. This study is of particular practical interest in connection with the sweat-cooling of turbine blades and of airfoil surfaces in high-speed flow. The method of analysis consists of applying the Kármán-Pohlhausen method to both the momentum and energy boundary-layer equations and of using an additional heat balance equation, involving the coolant temperature. A closed-form approximate solution of the equations is then derived. Numerical examples for flow in the immediate vicinity of a stagnation point and for a typical type of flow over a turbine blade are given.

A Second-Order Solution for an Oscillating Two-Dimensional Supersonic Airfoil

By

Alexander Wylly

The RAND Corporation

This paper presents a second-order solution for the forces and moments produced by an oscillating two-dimensional airfoil of arbitrary cross section. This solution, valid to the second order in angle of attack and thickness, is obtained by means of an iteration procedure.

One part of this paper is concerned with the development of a linearized (or first-order) velocity potential, which is of suitable form for use in the iteration procedure. This velocity potential is developed as a power series approximation, in frequency, to the exact linearized solution. The first six terms of this series are shown to be within a few per cent of the complete linearized solution when the reduced frequency ($\bar{\omega} = \omega\bar{C}/\beta^2 V_0$) is less than 1.3.

The second part of this paper is devoted to the development of the second-order solution in angle of attack. This latter is developed with the use of the above-mentioned series approximation to the linearized solution, and, since the linearized solution valid to the second order in frequency was utilized in the iteration procedure, the final solution is valid to the second order in angle of attack and frequency.

The second-order terms were found to have a relatively strong influence on the final solution, particulary for the pitching moment. It will be seen that in many cases the second-order terms are larger in magnitude than the corresponding first-order terms and, thus, reverse the tendencies indicated by first-order theory. In particular, it was shown that the theoretical instability predicted by linearized theory for an airfoil of zero thickness is completely eliminated for an airfoil having a thickness ratio as small as $4\frac{1}{2}$ per cent.

The damping moment for a $7\frac{1}{2}$ per cent thick airfoil was compared with that given by British experimental test. The second-order solution is shown to be in much better agreement with the experimental data than is the linearized theory; however, the magnitudes of the damping moments predicted by second order theory are appreciably lower than those indicated by experiment.

Analysis of Oval Rings by Fourier Series

By

Roland J. Benjamin

University of Illinois

The distinguishing feature of this method of analysis of thin oval rings is the representation of the shape of the ring by the use of Fourier series. By means of standard computational schemes, the coefficients of Fourier series of sine and/or cosine terms may be so selected as to cause the graph of the function represented by the series to approximate closely the shape of the ring under consideration.

Once the ring has thus been represented by an analytical expression, any of the common strain energy methods may be employed in the solution of the problem. Because of its simplicity, the method of elastic weights is used herein, and a sample problem of a general oval ring subjected to concentrated loads is worked out.

The possibilities of application of the method to fuselage ring design are pointed out by the solution of the problem of an elliptical ring subjected to a concentrated load and help in equilibrium by distributed skin forces.

The accuracy of the method, established by analyzing true elliptical rings whose solutions are already known, is high. To reduce computation, some of the higher harmonics of the Fourier series may be neglected with but negligible effect upon the result.

The method is a general one and may be applied to rings having two, one, or no axes of symmetry.

Please do not order Preprints of these papers at this time.
See page 44 for Preprints that are immediately available.

Flutter Analysis of Complex Airplanes by Experimental Methods

By

E. Berkeley Kinnaman

Boeing Airplane Company

The analysis of the flutter potentialities of a highly elastic airplane having a wing of high aspect ratio with large flexibly mounted concentrated masses distributed along the span has proved to be amenable to solution by the use of elastically and dynamically scaled wind-tunnel models. Experimental flutter testing at Boeing has progressed from a simple half-wing cantilever model of 1946 to today's almost

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completely scaled flutter models tested in reasonable simulation of free flight.

Continued development of experimental flutter analysis techniques and correlation with full-scale flight testing and theory is needed to permit more accurate predictions of the flutter characteristics of an airplane prior to the final design and flight stages.

Preprint No. 363

Two-Dimensional Transient Motion and Flutter of a Wing Having Four Degrees of Freedom

By
Herbert Reismann and Gilbert C. Best
Consolidated Vultee Aircraft Corporation

This investigation formulates the flutter problem of a wing-aileron-tab combination with aerodynamic overhang in terms of a system of six linear ordinary differential equations of motion with constant coefficients. The coefficients are functions of the airplane parameters and may ultimately be expressed as functions of the forward speed of the airplane. An investigation of the stability of the solution of this system of differential equations as a function of the forward speed will yield the flutter speed, as well as the flutter frequency.

Two-Dimensional Airfoils at Moderate Hypersonic Velocities

By
William H. Dorrance
Consolidated Vultee Aircraft Corporation

Expressions for lift, drag, and pitching moment coefficients are derived for a large number of airfoil sections in two-dimensional hypersonic flow. These expressions, differing from those obtained using linearized, second-order, and third-order theories, can be used throughout a moderate range of hypersonic Mach Numbers. The fundamental parameter of these formulas is the two-dimensional hypersonic flow similarity parameter, $K = M_0\delta$. To obtain these expressions, the shock-wave and expansion-wave equations for pressure ratios across such waves are expanded in powers of K. Following this, it is shown that the first three terms so obtained for both wave types are practically identical for values of K less than about 1.0. Further, it is shown that they closely approach the exact pressure ratio expressions. The application of the expressions thus derived to various airfoil sections is then demonstrated, and a table of airfoil coefficients is presented. It is shown that the airfoil formulas can be applied to finite wings with reasonable accuracy for design estimations.

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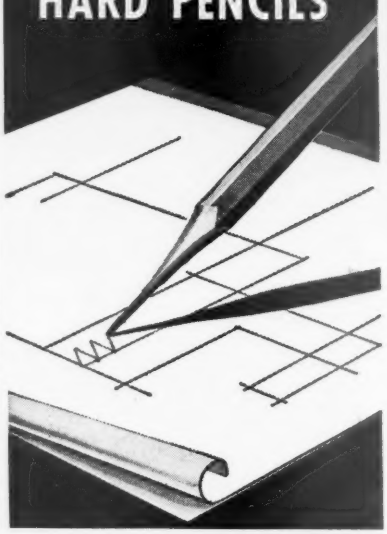

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A Method for Reducing the Analysis of Complex Redundant Structures to a Routine Procedure

By
L. B. Wehle, Jr., and Warner Lansing
Grumman Aircraft Engineering Corp.

A general method based on minimum strain energy is given for the analysis of statically indeterminate structures. Matrix methods are used throughout.

The procedure divides the work into three phases: (1) the writing of the equilibrium equations that determine the load distribution in the structure after it has been made statically determinate; (2) the tabulation of the flexibilities of the individual members comprising the structure; (3) the self-checking matrix operations, which can be performed in a routine manner. In connection with phase (2), formulas and curves are provided for some of the elements used most frequently in idealizing aircraft structures.

The method has been applied at the design stage to various components of several modern aircraft. For purposes of demonstration, a simplified example is worked out in this paper. The structure representing the root portion of a swept-back wing, having taper in plan form and thickness and nonparallel tapered bulkheads, is idealized, and its load distribution and deformation characteristics are obtained.

Preprint No. 361

The Development of Cascade Profiles for High Subsonic Potential Flows

By
Hsuan Yeh
The Johns Hopkins University

A method for developing cascade profiles for high subsonic potential flows to satisfy prescribed inlet and exit flow conditions and approximately prescribed cascade solidity is given. The method is based on the assumption that the compressibility of a gas can be represented by a linear pressure-volume relation (the Kármán-Tsien approximation). It is shown that with the proper selection of this pressure-volume relation, the error in specific volume in the linearizd gas as compared to an isentropic gas at the same velocity is less than 2 per cent of the isentropic stagnation specific volume for Mach Numbers between aproximately 0.4 to 0.9. An example shows that this Mach Number range covers almost the entire length of the cascade profile for an inlet Mach Number of 0.7 and a deflection of 22°. The deviation of the fluid angle from the blade angle at exit and the influence of inlet Mach Numbers on deviation are found to be in substantial agreement with previous experimental results.

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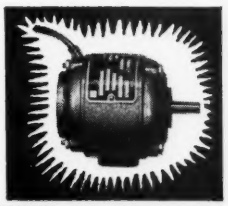
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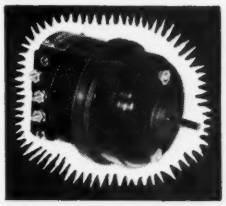
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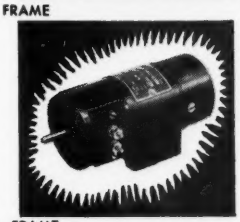
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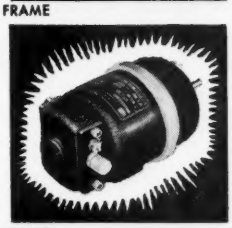
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Furthermore, the 2-man crew need never have seen the bomber they destroyed.

Today these all-weather jet interceptors are being delivered to the U.S. Air Force for 24-hour duty guarding U.S. borders and key cities. It gives the Air Force a fast-climbing jet fighter that is almost automatic—forerunner of planes that may actually fly and fight by themselves.

The *Starfire's* brain center can locate invading bombers on the darkest, stormiest night. Its unique all-rocket armament can destroy the biggest bomber built.

The *Starfire* is another example of Lockheed design "stretch"—an engineering achievement of creating a more advanced model out of an existing airplane. This speeds development and production, also cuts cost. Forerunner of the *Starfire* is the Lockheed F-80 *Shooting Star* of Korean fame. Lockheed is the world's leading builder of jet aircraft.

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STARFIRE NEARLY AUTOMATIC FIGHTER

On the opposite page you see illustrated in action the nearly automatic Lockheed *Starfire* (F-94C). This all-weather jet fighter is an electronics masterpiece with an interesting development history.

The "C" is the third in the *Starfire* series and is now being delivered to the U. S. Air Force to augment squadrons of F-94A's and F-94B's now on 24-hour duty as protection for such key cities as New York and Washington.

The evolution of the *Starfire* actually dates from the spring of 1945, when Lockheed developed America's first operational jet fighter, the F-80 *Shooting Star*. From the F-80 came the T-33 two-place jet trainer now used to train 9 out of 10 U. S. jet fighter pilots (also pilots from 9 other nations).

In turn the T-33 was redesigned to incorporate the most advanced electronic equipment known as well as some unknown devices that had to be specially invented. This became the U. S. Air Force's F-94 *Starfire*, now developed to the point where it both flies and fights with more than human accuracy. It has an all-rocket armament—no guns!

Electronics innovations include the Westinghouse Autopilot and Sperry Zero Reader. It is one of the few fighter-type planes equipped with ILS (instrument landing system) for low-visibility landings. *Starfires* pack 1200 pounds of electronics, compared to 168 pounds of radio in the Lockheed P-38 of World War II.

The *Starfire* is the first production aircraft to fly with the new Pratt & Whitney J-48-P-5 jet engine. Its afterburner provides extra power for rapid take-off and extra performance in battle.

The F-94C is the largest of the original Lockheed jet series. The statistics: take-off weight, over 20,000 pounds; length, 41 feet, 5 inches; wingspan, 37 feet, 6 inches; height, 13 feet, 7 inches.

A pioneer in the jet field, Lockheed has produced more jet aircraft than any other manufacturer.

Investigation into the Operating Cycle of a Two-Dimensional Supersonic Wind Tunnel

By

G. V. Bull

Institute of Aerophysics, University of Toronto

The operating cycle of an intermittent supersonic wind tunnel, while probably recognized, has never been defined rigorously. In this paper, the wind-tunnel operating cycle is divided into five distinct phases based on the character of the flow along the wind-tunnel axis. These phases are, in cyclic order, the nonstationary starting phase, the quasi-stationary starting phase, the stationary phase, the quasi-stationary closing phase, and the nonstationary closing phase. The first of the starting phases is treated both theoretically and experimentally for the case of the opening valve located downstream from the working section and experimentally for the case of the valve located upstream from the nozzle throat. These theoretical studies are based on an assumed wave pattern (subsequent to the breaking of the diaphragm), determined from results of shock-tube investigations and by application of an approximate theory for the solution of two-dimensional nonstationary flow problems due to Guderley. The quasistationary starting phase is studied theoretically by extending the stationary supersonic-subsonic jet theory in which the jet exit static pressure is less than the pressure in the region into which the jet is issuing. The theoretically postulated state of affairs during these phases is verified by obtaining experimentally a measured series of shadowgraphs and, thereby, determining the time history of the wind-tunnel starting process. The effect of condensation of water vapor on these phases is studied experimentally.

A Mixing Theory for the Interaction Between Dissipative Flows and Nearly Isentropic Streams

By

Luigi Crocco and Lester Lees

Princeton University

By means of a simplified theoretical "model," the present paper treats the general class of flow problems characterized by the interaction between a viscous, or dissipative, flow near the surface of a solid body or in its wake, and an "outer" nearly isentropic stream. For the present, the external flow is taken to be a plane, steady, supersonic flow, which makes a small angle with a plane surface or plane of symmetry, although the methods used can be extended to curved surfaces, to axially symmetric supersonic flows, and also to subsonic flows. The

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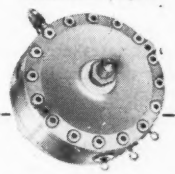

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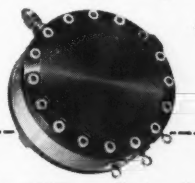

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internal dissipative flow is regarded as quasi-one-dimensional and parallel to the surface on the average, with a properly defined mean velocity and mean temperature. The nonuniformity of the actual velocity distribution is taken into account only approximately, by means of a relation between mean temperature and mean velocity. Mixing, or the transport of momentum from outer stream to dissipative flow, is considered to be the fundamental physical process determining the pressure rise that can be supported by the flow. With the aid of this concept, a large number of flow problems is shown to be basically similar, such as boundary-layer shock-wave interaction, wake flow behind blunt-based bodies (base pressure problem), flow separation in overexpanded supersonic nozzles, separation on wings and bodies, etc.

When the mixing rate is taken to be proportional to the mass flux density of the isentropic stream, the equations of motion are reduced to a single, nonlinear ordinary differential equation that can be integrated numerically. An important property of this equation is the existence of a "critical point" for supersonic wake flows, and, also, under certain conditions, for supersonic flows directed toward a solid surface. This critical point acts much like the "throat" of a nozzle in determining the base pressure, for example, or, in some cases, the surface pressure distribution in a boundary-layer shock-wave interaction. One important reason for the marked difference between laminar and turbulent flows is the fact that the turbulent mixing rates are from five to ten times larger than the laminar mixing rates.

By introducing several reasonable physical assumptions, a "simplified" form of the mixing theory is developed particularly for separated and reattaching flows and wake flows. Separating flows, as well as reattaching flows, are found to be capable of supporting considerable pressure increases at high velocities. The maximum compression, as measured by the isentropic flow deflection, is roughly proportional to the square root of the mixing coefficient, and also to $(M^2-1)^{1/}$ where M is some average Mach Number. Thus, the pressure ratio increases rapidly with the Mach Number, or the base pressure ratio; for example, it decreases rapidly with increasing Mach Number. In separated flows the pressure gradient along the surface is a maximum at separation and drops off steeply downstream; in reattaching flows, or wake flows, the pressure gradient is negligible some distance upstream of the "reattachment point" and increases rapidly toward a maximum as this point is approached. The inflected surface pressure distribution observed in laminar boundary-layer shock-wave interactions with flow separation is now understandable, and the distribution itself can be calculated approximately.

When the present mixing theory is applied to the problem of determining the base pressure for a supersonic airfoil with a blunt trailing edge, it gives the correct fluid-mechanical explanation of the observed phenomena. Qualitative agreement is found between the theoretical calculations of the curve of base pressure versus Reynolds Number and the data of Chapman and Bogdonoff on bodies of revolution, and Chapman's data on blunt trailing-edge airfoils. The theory is now being extended to axially symmetric supersonic flows.

The results obtained in the base pressure problem for a supersonic airfoil with a blunt trailing edge open the way for application of the mixing theory to boundary-layer shock-wave interactions, boundary-layer separation, and many other phenomena. However, the dependence of the mixing rate and the mean velocity-mean temperature relation for the dissipative flow region on the flow parameters must be carefully investigated experimentally and theoretically and the results incorporated into the analysis.

Partially Plastic Rotating Discs

By

Melvin Zaid

Sperry Gyroscope Division, The Sperry Corporation

The solution is obtained for the flat rotating disc in the plastic region. Strains are assumed to be small, and elastic compressibility is considered in order to avoid discontinuities at the elastic-plastic boundary.

The distortion energy theory is used, and results are obtained for both strain and nonstrain hardening materials.

Comparison is made to previous solutions based on the maximum shear theory and also to the numerical solutions obtained by Nadai and Donnell, all of which neglected elastic compressibility.

On Curved Shocks in Steady Plane Flow of an Ideal Fluid

By

C. Truesdell

Indiana University

For inviscid fluid obeying an arbitrary equation of state, the jump in the velocity gradient across a curved shock in steady plane flow is calculated. The results are expressed in terms of dimensionless variables. For the case of uniform oncoming flow, it is shown that the vorticity generated by the shock is a function of curvature, strength, and shock angle only, being independent of the form of the equation of state.

The Promise and Problems of Atomic Power

(*Concluded from page 29*)

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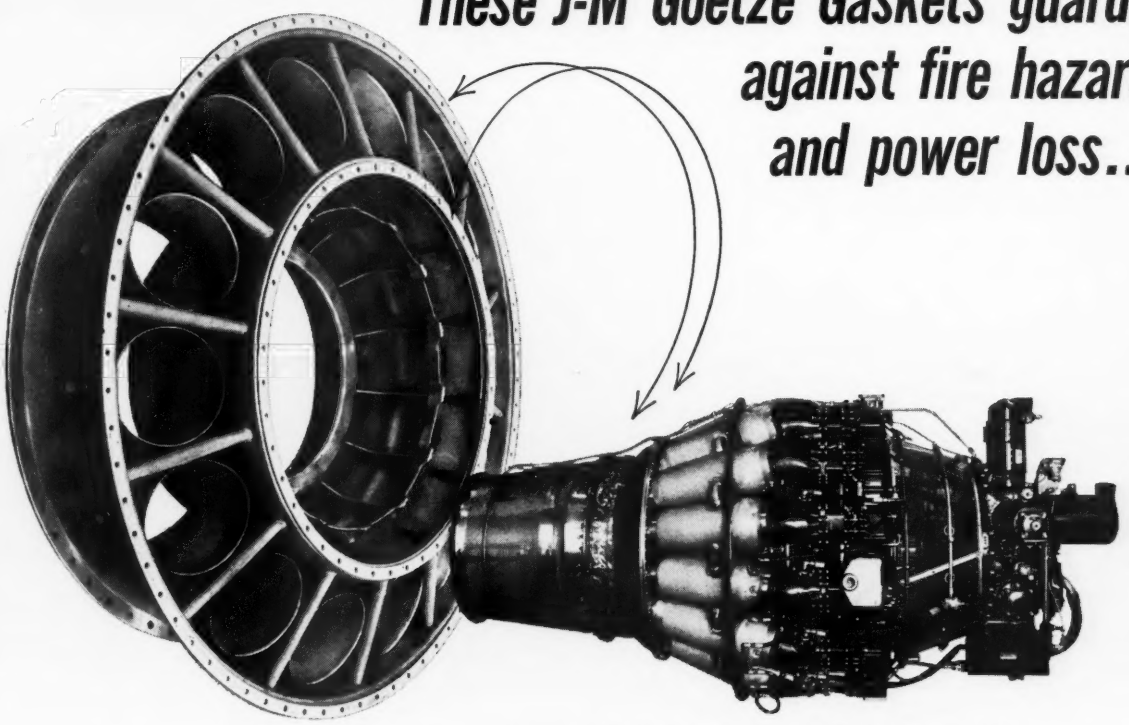
[18] Lilienthal, David, *Atomic Energy and American Industry*, talk before Economic Club of Detroit, October 6, 1947.

These J-M Goetze Gaskets guard against fire hazard and power loss...



Arrows point to J-M Goetze metallic gaskets on the inner and outer annulus, and their approximate location on the J33 turbojet engine turbine frame.

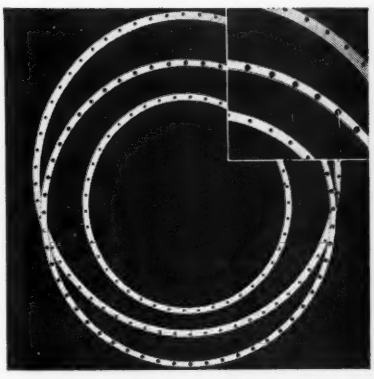
...on powerful turbojet engines like the J33

Sealing the inner and outer annulus on the J33 to prevent leakage of fuel and flame into the airframe is another example of the many tough, critical sealing jobs entrusted to Goetze custom-crafted metallic gaskets.

For this particular service condition, the Goetze gasket specified is made from a flat gasket design... with the metal on both edges rolled around an asbestos filler. This construction provides the resilience needed to overcome the warpage encountered in these applications. Like all Goetze gaskets, this style is precision-made to fit tight and stay tight in service.

There is a Johns-Manville Goetze gasket for practically every jet aircraft requirement. Goetze craftsmen can fabricate them in almost any shape or size for sealing igniters, compressor bleed-offs, cross ignition tubes, combustion chambers, fuel nozzles, turbine drain lines, etc. Backed by more than 60 years of Goetze "know-how," these durable gaskets are solving many of industry's most complex sealing problems.

Why not write for further information about Johns-Manville Goetze gaskets... and other J-M flight-proved products for the aviation industry. Ask for your copy of Brochure AV-1A. Address Johns-Manville, Box 60, New York 16, N. Y. In Canada, 199 Bay Street, Toronto 1, Ontario.



Close-up of J-M Goetze metallic gaskets used as inner and outer annulus gaskets on jet engine turbine frame.

JOHNS-MANVILLE JM PRODUCTS

Johns-Manville PRODUCTS for the AVIATION INDUSTRY

I.A.S. News (Continued from page 19)

dynamic theory. Mr. Davies was the recipient of the Edward Busk Memorial Prize for his paper on "Some Aspects of Flight Research."

I.A.S. Members Elected to Flight Safety Foundation's Board; Foundation Plans Expanded Safety Program

Three I.A.S. members were recently elected to serve on the Board of Governors of Flight Safety Foundation, thus enlarging and strengthening that body. The newly elected members are: Theodore P. Wright, I.A.S. Past-President, Honorary Fellow, and Founder Member, Vice-President for Research, Cornell University, and President, Cornell Aeronautical Laboratory, Inc.; J. Carlton Ward, Jr., M.I.A.S., Chairman of the Board, Thompson Industries, Inc.; and Reginald M. Cleveland, A.M.I.A.S., Industrial Advertising Manager, *The New York Times*, and President, Greater New York Safety Council.

The other members of the Board of Governors are: Richard T. Crane, A.M.I.A.S.; Rear Adm. Luis de Florez, U.S.N.R., I.A.S. Fellow and Founder Member; Paul M. Fitts, Jr.; Melvin N. Gough, F.I.A.S.; William Barclay Harding, H.A.I.A.S.; Jerome F. Lederer, F.I.A.S.; Ross A. McFarland, M.I.A.S.; David K. Morrison; Charles A. Rheinstrom; Harold K. Rulison; Murray Sargent, Jr.; Ed. H. Smith; and Harper Woodward, A.M.I.A.S.

Flight Safety Foundation recently put out a booklet entitled "Safety Has No Price Tag" for use in connection with Flight Safety's efforts to enhance the effectiveness of its work and to establish it on a sound basis of long-range planning and continuity. In this booklet, Flight Safety Foundation states:

"The necessity for extensive dissemination of statistics and information concerning flight safety is of greater importance today than ever before in the history of the industry.

"In recognition of this fact the Foundation has been directed by its enlarged Board of Governors to prepare a program of expanded activity that, through broader scope of operations, continuity, and cooperation, will provide benefits to the public and to all concerned commensurate with the great need that exists at this time."

The total cost of this program, as set forth in "Safety Has No Price Tag," has been put at $200,000 for the first year. Accordingly, Flight Safety Foundation is seeking the financial support of the principal elements of the aviation industry, "who will largely benefit from the adoption of this intense effort on behalf of safer flying."

Through one of Flight Safety's sponsors, the consulting services of Joseph E. Lowes, Jr., have been secured.

Necrology

Richard L. Bartlett

Richard L. Bartlett, A.M.I.A.S., died during the month of April, 1952. He was 40 years of age.

A native of Indianapolis, Ind., Mr. Bartlett completed high school in 1930 and then entered Indiana University. He left school the next year to enlist in the U.S. Navy where he remained until his discharge in the fall of 1935. During the next 4 years, he was in the employ of Consolidated Aircraft Corporation in capacities ranging from Dispatcher to Loftsman. In 1939, he was appointed Progress and Planning Director (on a civilian status) with the Assembly Division of the Naval Air Station, North Island, San Diego. During this latter period, he enrolled as an aeronautical engineering student in the University of California Extension at San Diego State College.

In December, 1941, Mr. Bartlett was commissioned a Lieutenant (j.g.) in the U.S. Naval Reserve and placed on active duty. He was promoted to his final rank of Lieutenant Commander in October, 1945. With the exception of the year 1946, he remained with the Navy until he was discharged in 1950 during a Government retrenchment program. During 1946, he served as civilian Head of the Metal and Machine Division of the Marine Corps installation at El Toro, Calif., and as Assistant Chief Inspector of the War Assets Administration's San Diego Regional Office.

After his 1950 discharge from the Navy, Mr. Bartlett became Engineer Liaison Representative between Bell Aircraft Corporation and Consolidated Vultee Aircraft Corporation's Fort Worth Division. At the time of his death, he was Field Service Engineer with AiResearch Manufacturing Company, Division of The Garrett Corporation.

Mr. Bartlett is survived by his widow.

John Edmund Hodgson

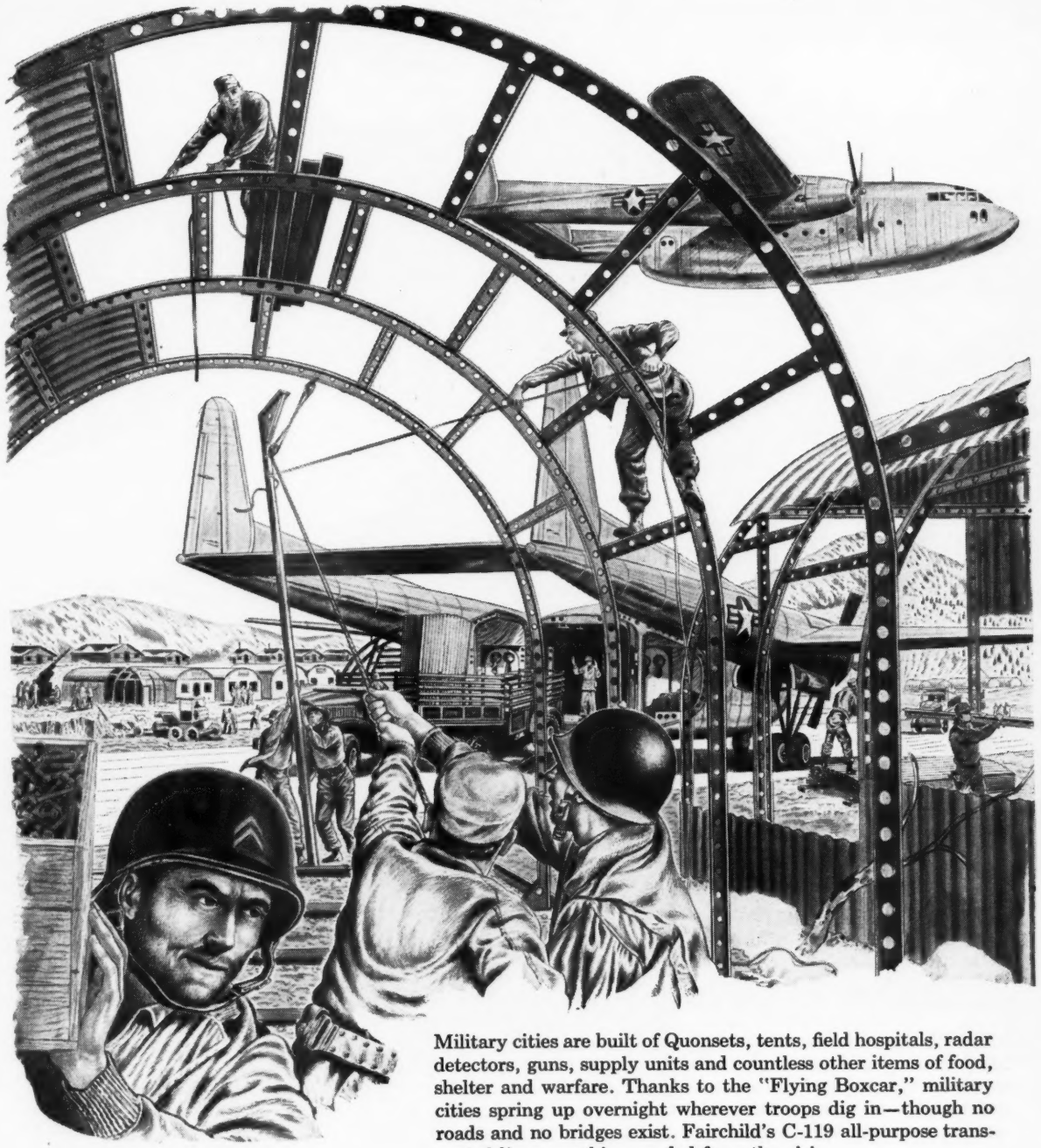
John Edmund Hodgson, Honorary Librarian of the Royal Aeronautical Society since October, 1923, died on last April 10 at Milestones, Bidborough, England. Mr. Hodgson had been in failing health during the previous year.

Born in Anerley, Surrey, England, on April 11, 1875, Mr. Hodgson attended Tunbridge School, England, and began his business career in Bickers, a book concern located in London's Leicester Square. Within a short time, however, he joined the old family firm of Hodgson & Compay, Book Auctioneers, of which he ultimately became Senior Partner.

Mr. Hodgson's intense interest in books and in the words of which they are made led him in due time to writing the history of aeronautics. Many of his works in this field were published either in book form or as magazine articles, but the one for which he is perhaps best known is "The History of Aeronautics in Great Britain, from the Earliest Times to the Latter Half of the Nineteenth Century," which was published by the Oxford University Press in 1924. He edited the "Aeronautical and Miscellaneous Note-Book of Sir George Cayley" and for the 12 months prior to his death had been working on a life of Sir George, as well as on a catalog of some Johnsoniana.

A collection of old ballon prints and posters and other rare souvenirs of the early development of aviation in Great Britain, which Mr. Hodgson made over the years, became a permanent exhibit of the Royal Aeronautical Society in 1947.

Mr. Hodgson was an Associate Fellow of the Institute of the Aeronautical Sciences and an Honorary Fellow of the Royal Aeronautical Society. He is survived by his widow, Mrs. Norma Hodgson.



Military cities are built of Quonsets, tents, field hospitals, radar detectors, guns, supply units and countless other items of food, shelter and warfare. Thanks to the "Flying Boxcar," military cities spring up overnight wherever troops dig in—though no roads and no bridges exist. Fairchild's C-119 all-purpose transport *delivers* anything needed from the air!

CITIES THAT ARE *Built in a Day*

Speed, stamina, versatility—the "Flying Boxcar" has demonstrated them all over tough battle-torn Korea. Backbone of the airlift, the Fairchild C-119 is number one all-purpose transport for military operations of UN forces in Korea, in Europe and in the United States.

ENGINE AND AIRPLANE CORPORATION

FAIRCHILD *Aircraft Division*

Hagerstown, Md.

Other Divisions: **Engine Division,** Farmingdale, N. Y. **Stratos Division,** Bay Shore, L. I., N. Y. **Guided Missiles Division,** Wyandanch, L. I., N. Y.

News of Members

▸**William B. Bergen** (A.F.), Vice-President and Chief Engineer, The Glenn L. Martin Company, was elected the 1952 National Chairman of the Aircraft Technical Committee, Aircraft Industries Association of America, Inc.

▸**Harold J. Carrick** (M.), who until recently was Professor of Aeronautical Telecommunications and Air Traffic Control, Instituto Tecnologico Aeronautica, São Jose dos Campos, Brazil, was appointed International Services Officer, Civil Aeronautics Administration. In this capacity, Mr. Carrick is responsible for organizing and staffing Civil Aviation Missions assigned to foreign governments under Mutual Security Administration and Technical Co-operation Administration programs.

▸**Dr. Chieh-Chien Chang** (M.), who was recently awarded a fellowship by the John Simon Guggenheim Memorial Foundation, will leave for Europe in September to investigate the application of mathematics to aeronautical problems of high-speed aircraft and missiles. During the 1-year period of the Guggenheim grant, he will study in British universities and will lecture throughout England and other European countries. Dr. Chang is Associate Professor of Aeronautics, The Johns Hopkins University, and a Consultant with the U.S.A.F.'s Air Research and Development Command.

▸**Rear Admiral Luis de Florez,** U.S.N.R., I.A.S. Fellow and Founder Member, was honored by the Wings Club at the May 14 luncheon for his years as a flyer. Admiral de Florez, who is Chairman of the Board of Directors of The de Florez Company, Inc., was given his first airplane flight and instruction on May 14, 1912.

▸**Bernard Gross** (M.), Director of Laboratories, Rohr Aircraft Corporation, was elected Chairman of the Aircraft Research and Testing Committee—Western Region, Aircraft Industries Association of America, Inc.

▸**Robert E. Gross** (A.M.), President, Lockheed Aircraft Corporation, is serving on the 14-member Aircraft Industry Advisory Committee of the Munitions Board.

▸**Andrew F. Haiduck** (M.), Vice-President, Lear, Inc., assumed the duties of General Manager of Lear's Grand Rapids Division. Mr. Haiduck was formerly General Manager of the Lear-Romec Division.

▸**Frederic D. Jewett** (M.), Supervisor—Design and Development, The Glenn L. Martin Company, was elected Vice-Chairman of the Aircraft Research and Testing Committee—Eastern Region, Aircraft Industries Association of America, Inc.

Anglo-American Consultant

Christopher Dykes (A.F.), of Great Britain, has entered the consulting field for both British and American firms in the aircraft industry. Accordingly, he has established himself as Consulting Aeronautical Engineer with offices at 31, Pembroke Gardens, London, W.8, England. It is his ultimate intention to advise on all phases of aircraft activity; however, at this time he will specialize on air transport problems—e.g., the selection of new equipment. Mr. Dykes was Chief Development Engineer for British Overseas Airways Corporation.

Resigns as Chairman

Glenn L. Martin, I.A.S. Honorary Fellow, Founder Member, and Benefactor, has resigned from the position of Chairman of the Board of The Glenn L. Martin Company. He continues, however, as a major stockholder and a member of the Board of Directors, holding the title of Honorary Chairman of the Board. Mr. Martin has been active in aircraft manufacturing since about 1907 when he first began building gliders and pusher-type aircraft. Two years later, in 1909, he established one of the first aircraft factories in the United States. He learned to fly in 1908 and holds F.A.I. Pilot Certificate No. 56 and Expert Certificate No. 2.

▸**O. M. Mosier** (A.M.), Vice-President, American Airlines System, was installed as President of the Wings Club at a luncheon on May 14 which celebrated that organization's tenth anniversary.

▸**Wilbur C. Nelson** (A.F.), Professor of Aeronautical Engineering, University of Michigan, was appointed to serve on the university's Centennial Committee, which is composed of ten faculty members, each of whom represents one of the ten departments in the College of Engineering. This group, headed by Prof. Stephen S. Attwood and aided by a five-member alumni advisory group, is making the necessary arrangements for the centennial celebration of the inauguration of engineering courses at the University of Michigan. A convocation on October 23 and 24, 1953, will mark the opening of the centennial program.

▸**Walter H. Setz** (M.), Chairman, Committee on Participation in the 1952 F.A.I. World Soaring Championships, Soaring Society of America, was named by the S.S.A. to head the U.S. delegation to Madrid, Spain, June 30 to July 13. In addition to the soaring competition, this event included the annual meetings of the Organization Scientifique et Technique Internationale du Vol sans Moteur (O.S.T.I.V.) and the Soaring Commission of the Fédération Aéronautique Internationale (F.A.I.). Captain Ralph S. Barnaby, U.S.N. (Ret.), (F.), and Dr. Wolfgang B. Klemperer (F.), S.S.A. Directors, were also in attendance at the Madrid meetings.

Members on the Move

The purpose of this section is to provide information concerning the latest affiliations of I.A.S. members. All members are, therefore, urged to notify the News Editor of changes as soon as they occur.

Second Lieutenant Richard W. Barber, U.S.A.F. (T.M.), 64th Fighter Interceptor Squadron, A.P.O. 942, c/o P.M., Seattle, Wash. Formerly, Aviation Cadet, U.S.A.F., James Connally A.F.B., Tex.

L. S. Barksdale (M.), President and Owner, Barksdale Manufacturing Corporation, Los Angeles. Formerly, Vice-President and General Manager, Saval Division, William R. Whittaker Company, Ltd.

Another new development using

B. F. Goodrich Chemical *raw materials*

Seal made by Roth Rubber Co., Chicago, for Vapor Heating Corp., Chicago. B. F. Goodrich Chemical Co. supplies the Hycar rubber only.

Hot steam handled from coach to coach —WITH HYCAR'S HELP!

THAT flexible, metallic conduit pictured has a rough, tough job—carrying steam heated to 400°F., under 250 pounds pressure, for heating railroad coaches.

Connected between cars, it has eight swivel joints to absorb jolts when the train rolls along. A seal at each joint must withstand the hot steam and vibration. And the seal manufacturer found that one made of Hycar, faced with asbestos, met all the severe requirements.

A natural choice, too, for Hycar has advantages that make it ideal for rugged service like this. Hycar rubber compounds can be made resistant to heat and cold, yet remain flexible and resilient under extreme temperatures. Hycar also resists water, weather, abrasion . . . gas, oil, many chemicals and more damaging factors.

Hycar may be the answer to your product development or improvement problems—the way to better, more saleable products. For helpful technical information on Hycar rubber compounds, please write Dept. HH-8, B. F. Goodrich Chemical Co., Rose Building, Cleveland 15, Ohio. In Canada: Kitchener, Ont. Cable address: Goodchemco.

B. F. Goodrich Chemical Company
A Division of The B. F. Goodrich Company

Hycar
Reg. U.S. Pat. Off.
American Rubber

GEON polyvinyl materials • HYCAR American rubber • GOOD-RITE chemicals and plasticizers • HARMON organic colors

Zelmar Barson (T.M.), Project Engineer, Aircooled Motors, Inc. Formerly, Aeronautical Research Scientist, Lewis Flight Propulsion Laboratory, N.A.C.A.

Olav Eggert Blichner (T.M.), Aerodynamicist, Norwegian Defence Research Establishment, Norway. Formerly, Graduate Student, University of Minnesota.

Commander Chester A. Briggs, U.S.N. (M.), Director, Experimental Program Division, Bureau of Aeronautics, Department of the Navy, Washington, D. C. Formerly, Executive Assistant to the Manager, Naval Air Factory, Philadelphia, Pa.

T. A. Cheatham, Jr. (T.M.), Pilot, Pan American World Airways, Inc., Edificio Panair, Aeroporto Santos Dumont, Rio de Janeiro, Brazil. Formerly, Pilot, Pan American World Airways, New York.

Shih-Fei Chiang (T.M.), Project Engineer, RCA Victor Division, Radio Corporation of America. Formerly, Student, University of California.

Hamilton Daughaday (M.), Head, Helicopter Research Section, Aero-Mechanics Department, Cornell Aeronautical Laboratory, Inc. Formerly, Engineer, Helicopter Research Section, Cornell Aeronautical Laboratory.

Mario Di Giovanni (M.), Chief Engineer, Statham Laboratories. Formerly, Chief Engineer and Vice-President, Robert Mayer Associates.

Roger D. Elliot (M.), Research Engineer "A," Special Weapons Division, Northrop Aircraft, Inc. Formerly, Research Engineer "A," Atomic Energy Division, North American Aviation, Inc.

Orren Y. Evans (T.M.), Stress Analyst, Consultants & Designers. Formerly, Draftsman "A," Allen Engineering Corporation.

Walter M. Fitch (A.M., H.A.), now B-47 Research Analyst, Methods Engineering, and Member, Materials Review Board, Wichita Division, Boeing Airplane Company.

Theodore J. Gordon (T.M.), Engineer, Gas Dynamic Facility, Arnold Engineering Center, ARO, Inc. Formerly, Graduate Assistant, Department of Aeronautics, Georgia Institute of Technology.

Jack L. Kirk (T.M.), Executive Engineer, Quality Control and Service Engineering Requirements Division, Beech Aircraft Corporation. Formerly, Field Service Representative, Wichita Division, Boeing Airplane Company.

Joseph I. Krebes (T.M.), now Manufacturing Engineer, Victor Adding Machine Company.

Dave E. Lukens (M.), Sales Manager, Pachmayr Gun Works. Formerly, Supervisor, Outside Production, Cessna Aircraft Company.

Archie Mooradian (T.M.), Engineering Draftsman "A," Northrop Aircraft, Inc. Formerly, 729th Bomb Sq., 452 Bomb. Wing, L, A.P.O. 950, c/o P.M., San Francisco.

Ensign Thurber A. Outlaw, Jr., U.S.N.R. (T.M.), Assistant Project Officer, Missile Division II, N.A.-M.T.C., Point Mugu, Calif. Formerly, Aeronautical Engineer, Airframes Branch, Aeronautical Engineering Group, Overhaul and Repair Department, Naval Air Station, Corpus Christi, Tex.

Major S. A. Oviatt (M.), Manager—Sales Engineering, Kentanium Products, Kennametal, Inc. Formerly, Account Executive, Gardner Displays Company.

Miss Ruth Mary Petry (M.), Research Assistant and Staff Member, Operations Research Office, The Johns Hopkins University. Formerly, Executive Assistant, Crash Injury Research, Cornell Medical College, New York.

Rogerio da Silva Rego (T.M.), Assistant to the Production Superintendent, Ford Motor Company

Proved IN MANY SERVICES

Lamb Electric

SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

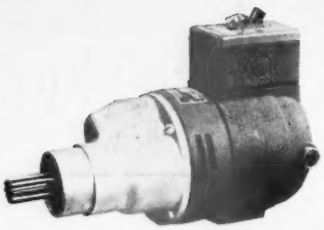
• Typical of the fields in which Lamb Electric Motors have gained a reputation for outstanding performance, are aircraft components, business machines, industrial and commercial equipment, household appliances, machine tools and portable electric tools.

Back of the good performance of Lamb Electric Motors is the fact that each motor is designed for a particular product or device, thereby insuring exact mechanical and electrical requirements.

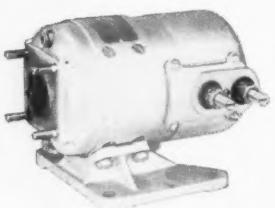
In addition to providing dependability, this *special engineering* usually results in savings in space, weight and cost factor.

The Lamb Electric Company
Kent, Ohio

THEY'RE POWERING
AMERICA'S *Finest* PRODUCTS



Geared head motor with reversing switch, adaptable to many heavy-duty, slow-speed applications.



Motor with high horsepower to low weight factor for either direct drive or use with external gear reduction.

Lamb Electric
SPECIAL APPLICATION FRACTIONAL HORSEPOWER MOTORS

Export, Inc., Brazil, S.A. Formerly, Chief of Production Inspection at São Paulo Air Depot, Parque de Aeronautica de São Paulo, Brazil, S.A.

Joseph T. Santy (T.M.), Junior Engineer, Production Engineering Group, Kaiser Metal Products Company. Formerly Mathematician "B," North American Aviation, Inc.

Kelsey Walker, Jr. (T.M.), Aerodynamicist, Aerodynamics Research Group, Douglas Aircraft Company, Inc. Formerly, Research and Teaching Assistant and Graduate Student, Massachusetts Institute of Technology.

Robert H. Wendt (A.F.), Vice-President, Kekhaefer Aeromarine Motors, Inc. Formerly Vice-President and General Manager, Aircraft Division, Globe Corporation.

R. J. B. Woodhams (M.), Chief Designer, Air Service Training Ltd., England. Formerly, Assistant Chief Designer, A.S.T. Ltd.

Corporate Member News

• **Aluminum Company of America**... A German-made 15,000-ton forge press, on lease from the U.S. Air Force, is now in operation at Alcoa's Cleveland Works for the production of large aluminum and magnesium forgings for aircraft. This press was constructed in the early part of World War II by Schloemann Company of Dusseldorf, Germany, for use in that nation's wartime light-alloy industry. It was installed in the Hanover, Germany, plant of Vereinigte Leichtmetall Company where it was used to turn out forged aluminum-magnesium aircraft parts. The press was ultimately dismantled and shipped to this country through the efforts of the U.S.A.F., previous arrangements having been made with Alcoa for its installation at Cleveland. The press, completely overhauled and refinished throughout, is a thoroughly modern machine supported with the best of heating and handling facilities. This press is part of a $13,200,000 expansion program to enlarge the Cleveland Forge Plant... Matt. W. Stanley was recently appointed to the position of Assistant Treasurer. He will also act as General Assistant to the Alcoa Vice-President.

• **Bell Aircraft Corporation**... Production of military and commercial helicopters began during May at the Bell Helicopter Division's new $7,000,000 plant at Hurst, Tex., from which all production and acceptance flight tests are scheduled to be made. The formal inspection of this plant, believed by Bell to be the first plant in the country built specifically for helicopter production, was held on June 6. Ground-breaking ceremonies on this site were conducted on May 21, 1951. The Bell plants at Saginaw, Mich., and at North Fort Worth, Tex., will operate as supporting facilities for the Hurst plant.

• **Canadair Ltd.**... Roger I. Harris was elected a Vice-President and Counsel of General Dynamics Corporation and Assistant to the Chairman of the Board of Canadair, a subsidiary of General Dynamics (formerly, Electric Boat Company).

• **Consolidated Vultee Aircraft Corporation**... The new $3,000,000 Convair Engineering Center in San Diego was formally dedicated on May 28. This building, the construction of which was started in June of 1951 and was completed 6 months later, houses thousands of engineering and technical personnel engaged in design, research, and development of aircraft, guided missiles, electronics, and related products.... The U.S.A.F. has ordered "a fleet" of T-29D bombardier training aircraft. This latest T-29 modification is based on the design of the T-29B and will be powered by two Pratt & Whitney 2,500-hp engines. The gross weight of the "D" will be over 40,000 lbs.

• **Continental Motors Corporation**... Clarence J. Reese, President of the corporation, was recently elected a Director of Lear, Incorporated.

• **Douglas Aircraft Company, Inc.**... According to a recent announcement, approximately 88 per cent of the skin on the Douglas DC-7 engine nacelles will consist of titanium sheet. Areas in which titanium will be utilized include the structural covering of the aft nacelles, some frames, and the landing-gear doors. Unalloyed titanium will also be used for firewall webbs.... Construction on a jet-silencer inclosure at the El Segundo Plant is expected to be completed by this September. The inclosure, 80 ft. long and 60 ft. wide, is being made of reinforced concrete and will accommodate full-scale airplanes as large as the A3D with its wings folded.

• **Fairchild Aircraft Division, Fairchild Engine and Airplane Corporation**... The C-119H, the newest in the Flying Boxcar series, took off on May 27 for its initial flight-test program. The C-119H incorporates various new features, such as redesigned wing, rough-field landing gear, exterior fuel pods, greater pay load, longer range, shorter take-off and landing characteristics, and lower paradrop and touch-down speeds. The C-119H is powered by two Wright R-3350-30W compound engines, each of which develops 3,500 hp.

• **The B. F. Goodrich Company**... An Air Force test program on a new jet-aircraft tire has been completed. With landings simulated at speeds up to 250 m.p.h., this new tire was still good after 50 landings. This new product is patterned after the new tubeless passenger-car tires recently announced.

• **Hamilton Standard Division, United Aircraft Corporation**... A simple ceremony to symbolize the start of manufacturing operations in Hamilton Standard's new plant at Windsor Locks, Conn., was held on May 29. The moving of personnel and equipment was begun on last April 16 and was completed in July. The new plant, for which ground was broken on April 19, 1951, contains some 880,000 sq. ft. This is Hamilton Standard's fifth move to new and larger quarters since it was first established in 1919 as Standard Steel Propeller Corporation in the Brushton section of Pittsburgh, Pa.

• **Harvey Machine Company, Inc.**... New quarters for Harvey Aluminum, a Division of Harvey Machine Company, have been opened in the Pure Oil Building, 35 E. Wacker Drive, Chicago.

• **Jack & Heintz, Inc.**... The recently released Technical Bulletin No. 1200 gives complete model data on Jack & Heintz generators and alternators. It also describes types of cooling systems used in these generators and alternators for aircraft, guided missiles, tanks, and ground power units. This 8-page bulletin is obtainable free of charge by writing to the company.

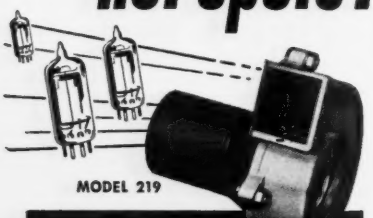
• **Lear, Incorporated**... Clarence J. Reese and Joseph H. McMullen were elected members of the Board of Directors at a recent shareholders' meeting. Mr. Reese is President of Continental Motors Corporation; Mr. McMullen is a Senior Partner of McMullen, Park, & Hard, members of the New York Stock Exchange.... At a recent meeting of the Board of Directors, Fred Harrison, of the company's division in Los Angeles, was elected as an Assistant Secretary.

• **Lockheed Aircraft Corporation**... Aircraft deicing equipment, said by the company to be "revolutionary," has been developed at Lockheed and is now undergoing flight testing. Made of metal, these new deicing boots incorporate an improved electrical design that can apply up to 75 watts per sq.in. The new metal boots can be used on both the wing and tail surfaces of military and commercial aircraft.... Following 2 years of research and tests of rivetless techniques of fastening metal parts together, a production department that would specialize in metal bonding is being planned.... The construction of a $1,300,000 factory for the final assembly of F-94 aircraft was scheduled to get under way sometime around the latter part of June. The site for this new structure is adjoining Lockheed's flight-test and delivery station at the U.S.A.F.'s proposed Palmdale jet center. Production here is scheduled to begin about March, 1952, after which component air-frame parts of the F-94 will be trucked to Palmdale from Burbank for final assembly.

• **Minneapolis-Honeywell Regulator Company**... Available on request from Honeywell's Aeronautical Division in Minneapolis is a new illustrated catalog that describes company-manufactured electrical connectors for the aircraft and other industries.

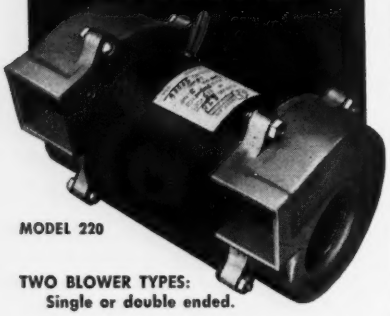
• **Northrop Aircraft, Inc.**... The new 153,000-sq.ft. final assembly building at Hawthorne, Calif., which was occupied last May several weeks ahead of the scheduled date, features a double assembly line for turning out F-89C's. This build-

cooling breezes
FOR
electronic hot spots!



MODEL 219

American Electric
Variable Frequency
MOTOR-BLOWERS



MODEL 220

TWO BLOWER TYPES:
Single or double ended.

Especially designed for spot cooling electronic equipment aboard aircraft. Unique design insures minimum watts loss over full frequency range of 320 to 1000 cycles.

In spite of wide frequency variations, the cfm output remains essentially constant at sea level. As pressure is reduced, the rpm increases, providing additional velocity of cooling air.

AIR DELIVERY: Blower heads available for any direction of air delivery.

Write for literature!

AMERICAN ELECTRIC MOTORS
TRADE MARK
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Los Angeles 22,
California

ing is a part of a 30 per cent expansion of Northrop's manufacturing facilities which was underwritten jointly by the U.S.A.F. and the company for approximately $5,300,000. Other parts of this expansion program include a tooling building, foundry, hangar, fuel-test building, and two mezzanines added to existing buildings.

• **Pan American World Airways, Inc.**... Three DC-6A cargo airplanes have been ordered from Douglas Aircraft Company, Inc., with delivery expected early in 1954. Each will carry a pay load of 25,000 lbs. in transoceanic service.... Robert L. Hamill, who has been a Partner of Sanderson & Porter since 1929, was elected a Director of Pan American.

• **Rohr Aircraft Corporation**...A standby credit of $7,000,000 has been arranged under an agreement with six banks guaranteed by the U.S.A.F. The credit expires on November 1, 1953.

• **Scintilla Magneto Division, Bendix Aviation Corporation**...A new device that is said to prevent successfully spin and creep of the outer race of a floating bearing has been announced. The Anti-Rotation Device, composed of a waved steel spring and a molded rubber ring, is designed to prevent outer-race rotation and thus eliminate damage resulting from this action. This Anti-Rotation Device is applicable to many fields (such as aircraft accessories, high-speed hand tools, electric motors, and other power tools) and is available for use with most popular-sized millimeter bearings.

• **Simmonds Aerocessories, Inc.**...G. J. (Gerry) McCaul has been promoted to the position of General Contracts Manager and is in charge of the company's branch offices located in Glendale, Calif.; Dayton, Ohio; Dallas, Tex.; and Washington, D.C. Prior to joining Simmonds in 1948, Mr. McCaul was with the U.S.A.F., Allison Division of General Motors Corporation, and Taylor Turbine Corporation.

• **Solar Aircraft Company**...A new toothless sawing method to reduce industrial accident, to save industry vast sums for expensive saw blades, and to reduce the use of scarce strategic metals in the making of new saw blades has been developed by Solar. The process is being revealed by the company to all industry as an aid in the national defense effort. It involves using ordinary steel box strapping without teeth as blades to saw stainless steel and other high-alloy sheets. Although only preliminary studies of the new technique have been made, early tests show: (1) that saw blades without teeth, made of cheaper materials than standard saw blades and without the strategic element content of the latter, will last for amazingly long periods when compared with ordinary saw blades; (2) that the toothless blades can cut stainless steel and high-alloy steels and have satisfactorily cut tool bits, files, and cobalt steel. The company says that the toothless blades work best at high speed and have been tested thus far only on band saws....A 5½-ton Ceruti horizontal boring mill, which was shipped from Italy to San Diego, has been loaned to Solar by the U.S.A.F., pending company receipt

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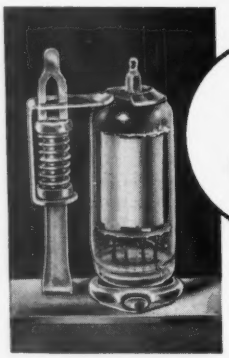
Hold Tubes in Sockets under all Vibration, Impact and Climatic Conditions

83 VARIATIONS FOR STANDARD TUBES



NEW CLAMP FOR MINIATURE TUBES

You can't shake, pull or rotate a tube out of place when it's secured by a Birtcher Tube Clamp. The tube is there to stay. Made of Stainless Steel, the Birtcher Tube Clamp is impervious to wear and weather.

BIRTCHER TUBE CLAMPS can be used in the most confined spaces of any compact electronic device. Added stray capacity is kept at a minimum. Weight of tube clamp is negligible.

Millions of Birtcher Tube Clamps are in use in all parts of the world. They're recommended for all types of tubes: glass or metal—chassis or sub-chassis mounted.

THERE'S A BIRTCHER TUBE CLAMP FOR EVERY STANDARD AND MINIATURE TUBE!

Write for samples, catalogue and price lists.

THE BIRTCHER CORPORATION
4371 Valley Blvd.
Los Angeles 32, Calif.

of machine tools now on order with American firms. This boring mill, which has a bed measuring 74 by 40 in., is now being used for the production of parts for the J-47 engine....A new descriptive folder, available upon request from Solar in San Diego, outlines the company's aircraft bellows designs and applications.

• **The Sperry Corporation**...The retirement of Thomas A. Morgan, A.M.I.A.S., as Sperry's Chairman of the Board and President was announced on May 21. These posts formerly held by Mr. Morgan have been filled by E. A. Pierce and H. F. Vickers, M.I.A.S., who were elected Chairman of the Board and President, respectively, at the May 21 organizational meeting of Sperry's Board of Directors. Mr. Pierce, who has been a Director of Sperry since its formation in 1933, is a partner in Merrill, Lynch, Pierce, Fenner & Beane. Mr. Vickers is Founder and President of Vickers, Inc., a subsidiary of The Sperry Corporation since 1937. Mr. Vickers is continuing as Vickers' President. Mr. Morgan is remaining with Sperry as one of its Directors. John Sanderson, formerly Vice-President for Finance and Treasurer, was elected Senior Vice-President and Treasurer. A Finance Committee of the Board of Directors was also appointed and is composed of J. Cheever Cowdin, Chairman; I. J. Harvey, Jr.; Mr. Pierce; Mr. Vickers; and Mr. Sanderson. Elected Vice-Presidents of the parent company are C. M. Green, Vice-President and General Manager of Sperry Gyroscope Company, Division of The Sperry Corporation, and Kenneth Herman M.I.A.S., Vice-President and General Manager and a Director of Vickers, Inc. ...A new bombing navigational computer, developed and manufactured by Sperry Gyroscope, was displayed to the public at Mitchel Air Force Base on Armed Forces Day. Informative meters and dials were, of course, masked from view. This device, in combination with a radar unit and periscope, navigates high-speed bombers to any desired target, seen or unseen, and bombs it accurately.

H. F. Vickers

• **Standard Oil Company (Indiana)**... David Graham, Financial Vice-President, and John E. Swearingen, General Manager of Production, were recently elected Directors of the company.

• **Stratos Division, Fairchild Engine and Airplane Corporation**...The new Stratos plant at Manor Lane and Orinoco Drive, Bay Shore, L.I., N.Y., was put into operation on June 9. The test section of this 140,000-sq.ft. plant, the cornerstone of which was laid in July, 1951, contains 27 test cells that permit the simulation of altitude conditions equal to those encountered at 55,000 ft. The compressed air capacity is 400 lbs. per min. at pressures up to 300 lbs. per sq.in.

• **Thompson Products, Inc.**...The annual awarding of ten scholarships to students of Case Institute of Technology has been announced. Each one of the scholarships provides the full amount of a year's tuition at Case plus the opportunity for summer employment at Thompson at current wage rates. The winners of the ten scholarships are selected each June, the first ones having been named this past June. When this program is in full operation, Thompson plans to award scholarships to four Case seniors, three juniors, two sophomores, and one freshman. The scholarships are renewable annually to current holders until graduation if the work and study performance meets the standards of the plan.

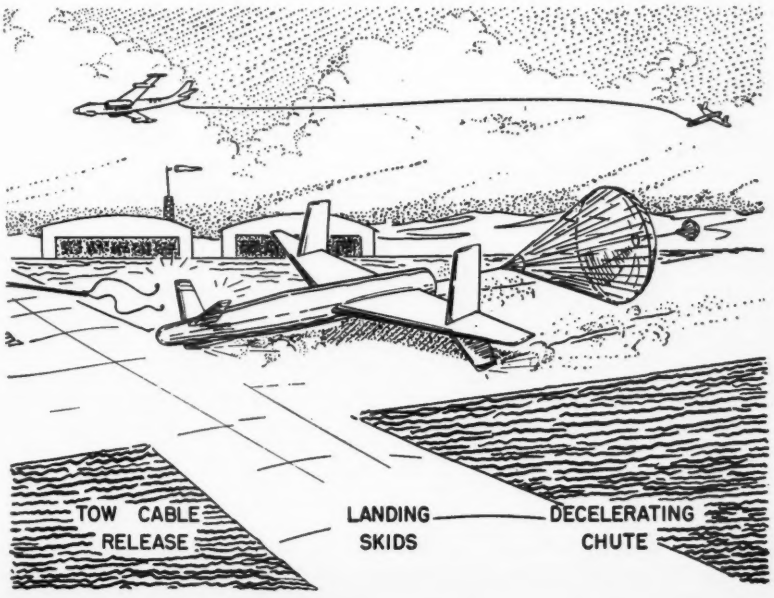
• **Trans World Airlines, Inc.**...A new sales office has been opened in Tokyo, Japan. The territory served by this office includes the Philippines, Formosa, and Okinawa, as well as Japan....T.W.A. has announced the opening of an office in Hong Kong, China.

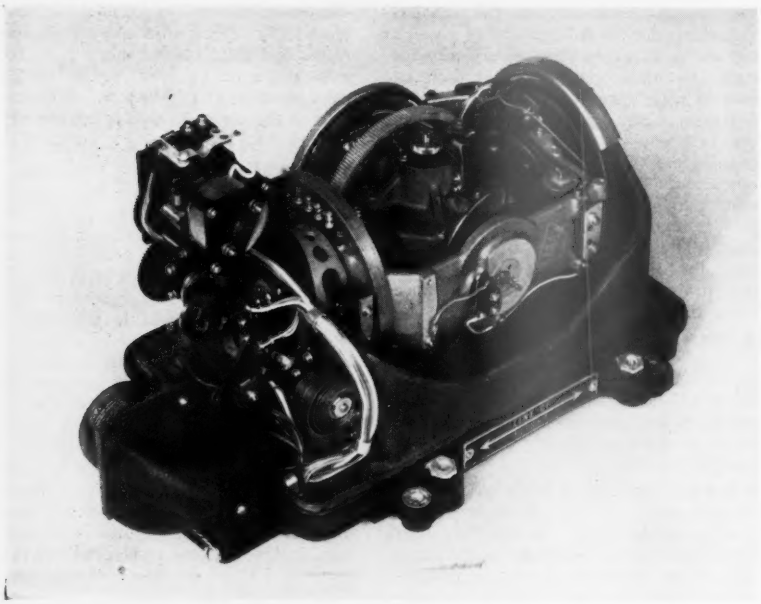
• **Vickers, Inc.**...A new feature incorporable in automatically pressure-compensated variable-delivery pumps has been announced. The company claims that now, when hydraulic power is not required during an intermittent duty operation, it is possible to depressurize the system by shutting off the pump by means of an electrical signal. When the pump is depressurized, input power to the pump is negligible and engine power and fuel savings are marked. There is no need in this particular design for mechanical clutches or disconnects. The sizes of these electrically depressurized 3,000-lbs.-per-sq.in. hydraulic pumps range from 0.32 gals. per min. at 1,500 r.p.m. to 23.8 gals. per min. at 1,500 r.p.m. A description of these new pumps is contained in Bulletin A5202.

• **Westinghouse Electric Corporation**... An anechoic chamber to enable research engineers to study the source, cause, and measurement of noise has been built into Westinghouse's new sound laboratory located in a suburban area of Pittsburgh. An insulating material fabricated from glass wool and shaped in the form of wedges, each measuring 8 by 24 in. at the base and 34 in. in length, covers the walls, ceiling, and floor of this echoless room in a checkerboard pattern. (The wedges are in groups of three. Thus, a group of three horizontally set wedges is surrounded in checkerboard style by groups of three vertically set wedges, and vice versa.) A sound level within the room of 10 to 15 db. is anticipated; the nocturnal noise level in the adjacent residential area runs between 25 and 30 db...A redesigned high-intensity runway light (HL) for outlining airport runways during night and bad-weather landings is now available. It operates from three independent 6.6-amp. series circuits and has a medium-intensity light in the top element and one of high intensity in each end....Ground was broken recently for a $6,000,000

Tow Target by Goodyear

An artist's conception of a "radically new and improved" tow target for jet-fighter gunnery practice shows the parachute-landing technique by which the new 30-ft. all-metal target may be returned to its base for further use. Under a U.S.A.F. contract that entails a year's program, Goodyear Tire & Rubber Company's Goodyear Aircraft Corporation is designing, developing, building, and testing several prototype tow targets capable of operation at high subsonic speeds and high altitudes. The target will be able to be towed as far as 2 miles behind its medium jet-bomber towplane. A control system to be employed will permit the target to perform evasive maneuvers either automatically or by direct control from the towplane. The work is being conducted in Goodyear's Aerophysics Department in cooperation with the Armament and Tow Target Unit, Equipment Laboratory, Wright Air Development Center, U.S.A.F., Dayton, Ohio.





Gyro Offers 2-Second Caging

A new-type cageable vertical gyro, introduced by Minneapolis-Honeywell Regulator Company, as a 2-sec. caging time and a special tumbling-pin construction that is said to permit unlimited freedom of rotation about the outer gimbal axis and a ±85° of rotation about its inner gimbal axis. Accordingly, this gyro ostensibly allows nearly unlimited aircraft maneuvering without the loss of its vertical reference. The instrument is applicable to autopilot systems, missile guidance, and radar-scanning stabilization and, with modifications, can be used as a directional gyro.

steam- and gas-turbine development laboratory at Westinghouse's South Philadelphia Works. Construction will begin late this summer and will be completed in about 1 year.... A new multimillion-dollar plant for the manufacture of watt-hour electric meters is being constructed at Raleigh, N.C. This plant, which will contain more than 500,000 sq.ft., is part of Westinghouse's $296,000,000 expansion program, the second such undertaking since World War II.

I.A.S. Sections

Baltimore Section

M. Francis Taylor, *Secretary*

The thirty-sixth meeting of the Baltimore Section was held on April 22 at The Johns Hopkins University.

The chairman called the meeting to order at 8:35 p.m. There were approximately 60 members and guests present. The secretary gave a brief résumé of the minutes of the previous meeting. No treasurer's report was available. At the request of Mr. Jewett, Chairman of the Nominating Committee, O. J. Schaefer presented the list of nominations. No additional nominations were offered from the membership. A motion was duly made, seconded, and approved by voice vote that the nominations be closed. The chairman requested all committee chairmen to present a written report of activities and any recommendations at the next meeting. It was again emphasized that our June meeting is to be a bang-up affair —cocktails, dinner, and Rear Adm. C. M. Bolster, Chief of Naval Research, to speak.

The chairman introduced the first speaker of the evening, L. E. Wood, Chief Engineer, Friez Instrument Division, Bendix Aviation Corporation. Mr. Wood used as his subject, "High Altitude Sounding System." The speaker's summary of his talk follows:

"The use of radiosondes for making high-altitude soundings of atmospheric pressure, temperature, and humidity has been in use on a regular basis for approximately 15 years and the present state of the art is well illustrated by a description of the 1,680-mc. system currently in production for and used by the armed services.

"This radiosonde employs a 1,680-mc. oscillator modulated by a blocking oscillator having a nominal frequency range of 10 to 200 cycles per sec. Meteorological intelligence is transmitted by means of an aneroid baroswitch which serves the two functions of measuring pressure and switching temperature, humidity, and reference circuits into the blocking oscillator grid circuit. The transmitted signal, therefore, consists of an essentially continuous 1,680-mc. signal suitable for direction finding, modulated with pulses of about 80-microsec. duration at a blocking oscillator rate indicative of pressure, temperature, and humidity measurements.

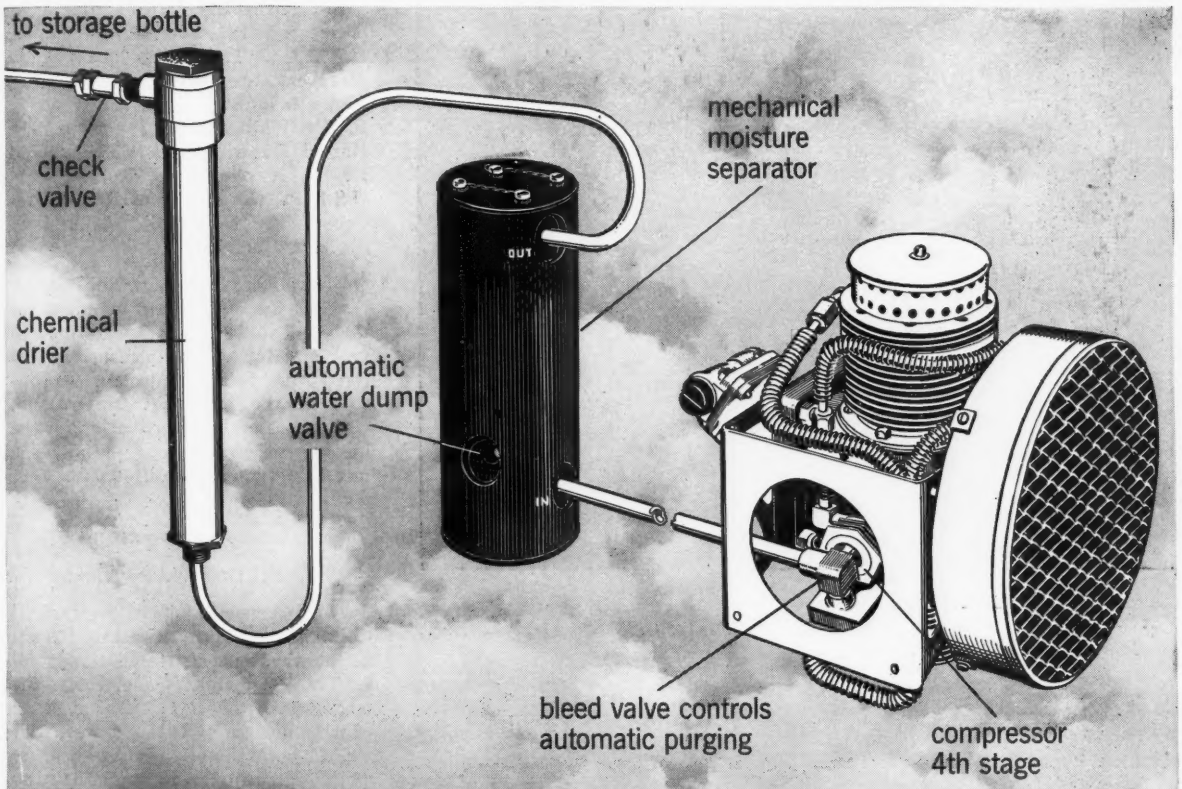
"The temperature and humidity measurements are made by means of a thermistor and an electrolytic resistor, respectively, whose resistances change with the elements in question.

"The signals are received on the ground by a parabolic antenna with which is associated a receiver and suitable servo mechanisms whereby the antenna automatically tracks the ballon in space and transmits signals to an angle recorder which records elevation and azimuth angles. From the receiver, signals are also fed into an electronic frequency meter and potentiometer-type recorder which records the temperature, pressure, and humidity data. From these two records can be evaluated the pressure, temperature, humidity, and wind speed and direction to altitudes of the order of 100,000 ft."

Following Mr Wood's talk, the chairman introduced Mr Brancato, of the local U.S. Weather Bureau, who, in turn, introduced Vincent J. Oliver, of the Extended Forecast Section, U.S. Weather Bureau, as the second speaker of the evening. Mr. Oliver spoke on "High Altitude Winds" The speaker reviewed briefly the means of determining wind velocities at altitude, mentioning photographs of antiaircraft shell bursts, rocket trails, clouds, meteor trails, and balloons, plus radar response. He exhibited pressure charts of the northern hemisphere at various altitudes for various seasons of the year and several individual day charts. The speaker discussed jet streams and vertical currents and coming down to lower levels; he also retold the story of the P-38 pilot who flew his ship as a glider for many minutes in the updrafts over the western mountains.

After a brief discussion period, mostly about local weather, the meeting was adjourned at 10:30 p.m.

▶The results of the recent election of the 1952–1953 officers are as follows, Chairman, A. J. Kullas, Supervisor: Structural Design Section, The Glenn L. Martin Company; Vice-Chairman, J. P. Paine, Chief Project Engineer, Aircraft Armaments, Inc.; Secretary, J. F. Maloney, Design Engineer, Aircraft Armaments, Inc.; and Treas-



this *KIDDE* dehydration equipment makes pneumatics work at 50,000 feet

Aircraft pneumatics systems don't *have* to freeze—even at 50,000 feet.

Kidde dehydration equipment, through processes of separation and drying, delivers compressed air to the storage bottles with a free air dew point of at least minus 65° F. Saturated air going into the compressor is 99.6% dry when it reaches the storage bottles. The accumulated moisture is released by automatic dump valves. When this happens the entire system from compressor to check valve is purged.

This special *Kidde* dehydration equipment, coupled with the new lightweight *Kidde* four-stage compressor, gives you a "workhorse" pneumatics system even at altitudes of 50,000 feet and through a temperature range of minus 65° F to 160° F.

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Boston Section Views Wind Tunnel

A general view of the some 200 persons who attended the April 16 meeting held at M.I.T.'s Naval Supersonic Wind Tunnel.

urer, L. F. Freitag, Landing Gear Design Engineer, The Glenn L. Martin Company.

Boston Section

E. E. Larrabee, *Secretary*

The April 16 meeting of the Boston Section was held in the Naval Supersonic Wind Tunnel at Massachusetts Institute of Technology. Professor John R. Markham, Director of the facility, gave a talk that described the tunnel; covered some of the problems encountered in its design, construction, and operation; and dealt with the general physical aspects of the flow in the tunnel circuit. Motion pictures, which demonstrated the development of supersonic flow in the test section, were shown. Following this, the tunnel itself was run, and all those present were able to see the shock-wave formation on an ogival shape. After the demonstration, members of the Supersonic Tunnel's staff answered questions about the operation of the tunnel and its associated equipment.

The unusual opportunity of seeing a large supersonic wind tunnel demonstrated undoubtedly accounted for the large turnout. More than 200 persons took advantage of this opportunity; some of them were workers in the tunnel who were able at this time to show their families this ordinarily classified military research facility. All agreed that the meeting was one of the most successful held by this section.

Chicago Section

Alfred F. Stott, *Secretary*

The Annual Meeting of the Chicago Section was held on May 14 at the Naval Air Station in Glenview, Ill. This was the fourth meeting held at this location and, as usual, an excellent time was had. The program started at 6:00 p.m. with a tour of the station. Lieutenant Colonel Harold Penne, U.S.M.C., was responsible for all the program arrangements, while Chief Robert Saxe was in charge of the tour. Approximately 70 persons enjoyed a well-conducted tour, which was followed by a social hour and dinner in the officers' mess. Ninety-two members, wives, and guests attended a fine turkey or roast beef dinner.

At 9:00 p.m., Section Chairman Robert H. Wendt called the meeting to order. He introduced Captain R. M. Oliver, U.S.N., Commanding Officer of the N.A.S. at Glenview. Captain Oliver welcomed the members and guests and outlined activities at the Station. A fine colored movie, *The Shores of Iwo Jima*, was shown.

Chairman Wendt then called upon Harold Wackelin, Chairman of the Nominating Committee, to read the proposed slate of officers for the coming year. No additional nominations were received. The proposed slate was adopted as read. The Officers and Board Members for the coming year are as follows: Dr. Harvard L. Hull, Chairman; Alfred F. Stott, Vice-Chairman; Charles L. Bonnette, Secretary; Lt. Col. Harold Penne, U.S.M.C., Treasurer. The Board Members are Robert H. Wendt, Kenneth L. Burroughs, Ray Brittan, B. R. Winborn, O. J. Engle, Dr. Harold Hawkins, Ben Vinecky, and Dr. R. N. Du Bois. Robert Saxe, U.S.N.R., was chosen as Representative to the Nominating Committee for Area Councilors.

The retiring Chairman, Bob Wendt, thanked the officers and members for their splendid cooperation during the year and told of the pleasure he derived from being Chairman. He introduced the new Chairman, Dr. Hull, who expressed his appreciation for the honor conferred upon him. The meeting adjourned at 10:30 p.m.

Columbus Section

S. A. Gordon, *Secretary*

The first meeting of the reorganized Columbus Section was held on April 29 at the Seneca Hotel. Approximately 100 members and guests attended the premeeting dinner, after which an election of officers was held. Dr. D. T. Williams, of Battelle Memorial Institute, presided as Acting Chairman.

Officers for the coming year are: Chairman, D. T. Williams; Vice-Chairman, M. M. Blair; Secretary, S. A. Gordon, and Treasurer, C. E. Rhodebeck.

After elections, Mr. Gordon introduced the speaker, Ernest Stout, Assistant to the Chief Engineer in Charge of Naval Aircraft Research and Sales, Consolidated Vultee Aircraft Corporation. His talk, "A Review of High-Speed Hydrodynamic Developments," was originally presented at the Third Anglo-American Conference at Brighton, England, in 1951. Mr. Stout emphasized the new concept of water-based aircraft which requires the elimination of the Naval Architect in hull design. An example of this is the high length/-beam ratio hull that, as he put it, "provides the only significant improvement in hull design since the NC-4." He illustrated his discussion of the use of Dynamic Similarity Hydrodynamic Models with two films. The first was Convair's *Annual Review of Hydrodynamic Research* and the second was a review of the development of Convair's water-based fighter, The Skate.

The meeting was concluded with a question-and-answer period that underlined the enthusiastic reception of Mr. Stout's talk.

Flying Tomorrow's Jets

Sperry research engineers are seeking solutions for tomorrow's flight control problems while they develop new ways to better the performance of control equipment currently flying.

This analog computer is duplicating flight conditions of a new high-performance jet bomber being "flown" automatically by the Gyropilot* flight control. Here, for instance, a Sperry engineer checks the performance of the airplane and automatic pilot during the bombing run.

In test after test – in laboratory and its great Flight Research Center, MacArthur Field, Long Island—Sperry flight controls are continuing to prove their capacity to maintain stable all-weather flight in jet, propeller-driven, rotary-wing, lighter-than-air and pilotless aircraft.

For 40 years Sperry has been working continually on flight control problems. With this wealth of experience to build on, tomorrow's problems are being met by today's research and engineering.

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Meet Your Section Chairman

David F. Berry

Atlanta Section

David Franklin Berry, Process Engineer concerned with the control of materials and processes used in airframe manufacturing at the Georgia Division of Lockheed Aircraft Corporation, originally started to train for a career in the automotive industry. However, after a year of college at Michigan Tech (1937–1938), he "was influenced by an uncle to go into aircraft." And, so began Mr. Berry's interest in the aeronautical field.

Mr. Berry says of his years in aeronautics: "My aircraft experience started with Kollsman Instrument Company in August, 1939, with whom I worked for approximately 2 years as Machine Shop Inspector. A desire to return to the Southeastern section influenced me to go with Vultee Aircraft, Inc., in Nashville, Tenn., in the same capacity. A new section was formed there called Factory Liaison which was a combination of engineering, production, and Tooling Liaison, and I went into this group. In 1943, when our contract was cancelled on the Vultee Vengeance Dive Bomber, I was transferred to the Fort Worth plant in Liaison Engineering where I worked until entering the service in July, 1944. I was in the Infantry and in the Military Government in Korea until July, 1946. Upon release from the service, I went back to college at the University of Alabama where I graduated in Aeronautical Engineering in December, 1949. When I was graduated, I went to work with Boeing, Wichita, as a Tooling Inspector and then as a Process Engineer until July, 1951, when I came to Lockheed, Georgia Division, as Process Engineer."

One of Mr. Berry's most interesting episodes, he says, was the reorganization of the I.A.S. section in Atlanta, Ga. In this connection, he writes: "I was responsible for the organization of the Atlanta Section of the I.A.S. which took place this spring and was elected Interim Chairman for the remainder of this session."

Mr. Berry, who was commissioned a U.S.A.F. Captain in January, 1951, is a member of the Bachelor's Cotillion in Birmingham, Ala., the city in which he was born in July of 1918. He tells us that he does enjoy golf, swimming, and loafing, but otherwise he claims to have no hobbies.

Hagerstown Section

Robert E. Braus, *Secretary*

The Hagerstown Section met in the Antrim Room of Hotel McLaughlin, Greencastle, Pa., on March 25. Chairman E. E. Morton presided. After a short business meeting, Mr. Morton introduced the speaker of the evening, S. Tremen, General Manager, Guided Missiles Division, Fairchild Engine and Airplane Corporation.

Mr. Treman, whose subject matter was classified as "Confidential," gave an interesting and informative talk on guided missiles, in general, and stressed particularly the types of missiles currently being tested and produced by Fairchild. His talk was illustrated by slides and motion pictures.

The meeting was concluded with a lively question-and-answer session.

▶The April 29 meeting was held in the Terrace Room of the Terrace Restaurant. A social session preceded the calling of the meeting to order.

Vice-Chairman E. R. Gelvin presided in the absence of Chairman Morton who was unable to attend for family reasons. (It was a $7^1/_2$-lb. boy!)

The minutes of the previous meeting were read, and Mr. Gelvin then asked for opinions as to whether meetings should be discontinued until fall. The membership voted to call the next meeting in September.

The meeting was then turned over to Allen Clopper, Chairman of the Program Committee, who introduced the speaker of the evening, Glen M. Hobday, Resident Advisory Engineer representing the English Electric Company at The Glenn L. Martin Company in connection with the production of the Canberra bomber in the United States.

Mr. Hobday began his talk by reviewing the history of the English Electric Company from the time it began aeronautical research and manufacturing in 1911 to the present. He showed the engineering departmental organization chart under which the Canberra was designed and pointed out the difference between the English and American approaches to engineering management. An interesting statement was made to the effect that the designer in England was not burdened by the need to estimate engineering schedules or to perform administrative duties as is so often the case in this country. He further stated that a rigid detail schedule is not set up for creative engineering, but rather the designer has more freedom to devote his entire thought to the task at hand.

Methods of structural testing were described by Mr. Hobday, and the difference between the English and American approaches to testing was discussed.

Mr. Hobday closed his interesting talk by describing some of the unique features of the Canberra bomber and the missions it had been originally designed to perform. He then invited questions and comments from his audience, and a lively discussion session ensued.

The meeting closed with the showing of a motion picture in color of the Canberra in flight.

Philadelphia Section

Emily D. Rogers, *Secretary*

The new officers of the Philadephia Section elected for 1952–1953 are: Chairman, Harry Tobey; Vice-Chairman, Dale Hamilton; Secretary, Emily D. Rogers; and Treasurer, LeYork Cheeseman.

San Francisco Section

Forest W. Fingerle, *Secretary*

The April 24 meeting of the San Francisco Section was held at Ramor Oaks. This was a student meeting at which two students delivered their papers in competition. The paper, "Hydraulic Analogy of Two Dimensional Gas Flow," by C. E. Hallum, of the University of California, won the Standard Oil Company $100 award. The presentation of this award was made to Mr. Hallum by John MacGregor on behalf of Standard Oil Company.

Two Navy films were shown. One delineated the role of the Navy in science. The other was a fine film showing aircraft carriers in action near Korea.

Aluminum sheet, extrusions, bar, tube, forgings, castings

and *all* the tapered sheet in the Northrop F-89 are made by

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ALUMINUM
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ALUMINUM COMPANY OF AMERICA
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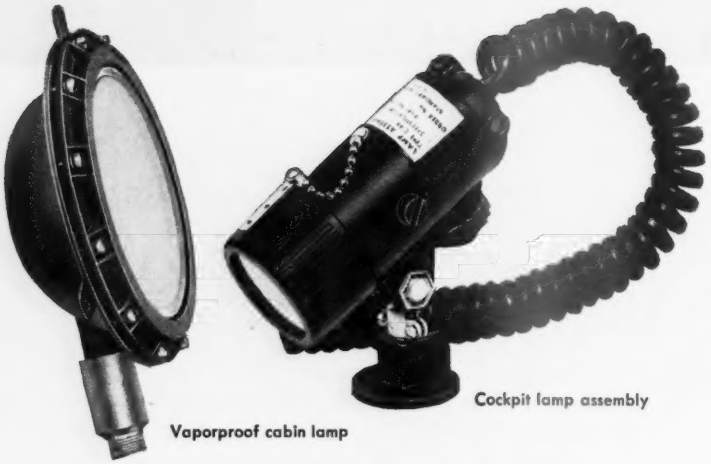
Standard-Thomson Cabin and Cockpit LIGHTS



Vaporproof cabin lamp

Cockpit lamp assembly

CABIN LAMPS: These all-metal cabin dome lights are proof against vapor or moisture at any altitude. Regardless of atmospheric conditions, they assure clear, brilliant light. Weight: 1 lb., 10 oz. Diameter: 5⅞″; length: 6⅞″. For complete information, write:

COCKPIT LAMPS: A sturdy source of dependable auxiliary light for all types of aircraft. Made to USAF specifications with chainlock filter and retractable cord. 13 or 28 volt bulb and rheostat. Weight: 11 oz.; length: 5 1/16″; diameter: 1¾″. Also available with straight cord.

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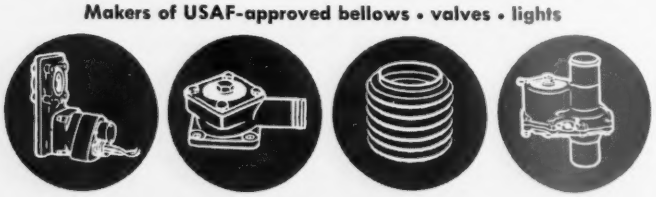
Standard-Thomson

Makers of USAF-approved bellows • valves • lights



Shut-off Valves | Barometric Pressure Valves | Tech-Forge Flexible Couplings | Crankcase Pressurizing Valve

Seattle Section

R. D. Fitzsimmons, *Secretary*

A lively, truly informative, and highly enjoyable dinner meeting and open discussion was held by the Seattle Section on May 14. Commander T. Davies, Head, Overhaul and Repair Department, Sand Point Naval Air Station, addressed the members on the subject "The Application of Operations Research in Airplane Design." Experience gained in the Bureau of Aeronautics, in the Office of Naval Research, and in the Office of the Assistant Secretary of the Navy for Air, in addition to experience in antarctic operations and in wartime and peacetime operations with antisubmarine aircraft, has given Commander Davies an inside picture of military aircraft operations, design, procurement, and requirements.

He outlined the meaningful mathematical approach to the problem of design through the use of a "singleness-of-objective" idea in contrast to the meaningless conclusions and pitfalls which can result through the use of "multiple superlatives." In other words, designing an airplane or laying out a specification for a design by mathematically optimizing or minimizing only one requirement gives a single result based upon a given set of assumptions. An example of this would be if the number of targets destroyed per dollar invested is the one requirement optimized. This method is in contrast to the concept wherein the airplane design, for example, is supposed to fly the fastest, the farthest, the highest, and carry the greatest pay load, which is truly a meaningless expression. Each could be optimized individually, but together they have no meaning.

Following a discussion of the ways in which the Navy is actively using operations research, Commander Davies commented a little about actual antisubmarine warfare and touched briefly on the sinking of submarines by aircraft during World War II.

Washington Section

J. H. Sidebottom, *Secretary*

We thought it might be of interest to other sections to know of six new features that were introduced into the Washington Section programs and plans for the past year. Some of these features may be new to other sections, and some of them we have borrowed in the light of success they have enjoyed with other groups.

▸**Meeting Arrangements and Planning**—This year, the Washington

Section planned its meetings on a subject basis rather than on an agency sponsorship basis. In previous years, it had been the custom to have the Air Force, Navy, C.A.A., N.A.C.A., etc., sponsor the meetings and to include papers for each meeting on various subjects. This year, the section endeavored to schedule a definite subject, such as supersonic flight, helicopters, personal aircraft, etc., and to obtain speakers from whatever agencies were interested in the subjects at hand. For each meeting, an honorary chairman was selected, and this chairmanship was rotated among high-ranking officers of the Air Force, Navy, or top administrators in the N.A.C.A., C.A.A., industry, etc. The officers believe that this method of confining the evening meeting to a single topic of discussion with several papers relating to the general theme increased the interest and attendance at the meetings.

Also, included in the planning for the meetings was joint society sponsorship of several of the meetings, as, for example, the Helicopter Meeting was handled cooperatively with the American Helicopter Society, while the Personal and Executive Aircraft Meeting was cosponsored by the Aircraft Owners and Pilots Association. The joint-meeting or cooperative-meeting plan has definite advantages in increasing the interest and attendance and in securing the best available speakers for a given subject. It is anticipated that future joint meetings with the A.S.M.E., S.A.E., American Rocket Society, etc., will be arranged.

The Washington Section has found that at least one or possibly two meetings a year should be devoted to field trips or visits to interesting laboratories or military installations. This year, the group visited the Naval Ordnance Laboratory; this was one of the largest meetings of the section for the year.

▸**Meeting Schedule Cards**—The officers of the section met early in the year and developed a schedule of meeting dates and locations for each of the six meetings to be held during the year. The date, time, and location for each meeting were printed on a wallet-sized card and distributed to section members prior to the first regular meeting in September as a reminder of all meetings to be held during the year. The subject of each meeting was not included, but this card served as a ready reminder for all section members and enabled them to mark calendars appropriately. Copies of these cards were also given to Attendance Committee representatives to distribute to new members or interested guests.

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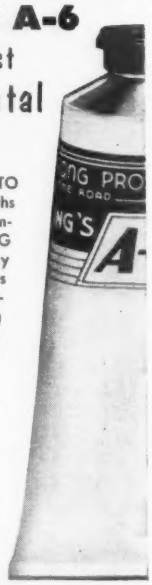

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▸**New Program Format**—One of the first steps taken by the Washington Section this year was to adopt a new program format similar in many respects to that used by the Los Angeles Section. We found that the program format on 8½ by 11-in. heavy paper with a return reservation card attached provided greater opportunity for the use of the announcement on bulletin boards, calendars, etc. The program is mailed in folded form and marked to the personal attention of the receiver. The larger type face used with modern art work makes it possible to highlight the featured events and, in addition, to provide for biographical notes on speakers and special announcements from the chairman. Although the program costs approximately $150 more than announcements sent out in previous years, the section officers felt that it contributed materially to the increased attendance at section meetings.

▸**Student Contest Paper Program**—A Student Contest Program was organized this year among the universities and colleges in the Washington area. This contest was open to all schools having engineering courses and included Catholic University, Howard University, George Washington University, University of Maryland, and University of Virginia. In the case of schools having I.A.S. student branches, contact was made directly with the Dean. Three excellent papers were received, though a number of others had been promised. Cash prizes were offered to the first and second papers, and both of the winning papers were briefed at the last meeting of the Washington Section. Next year, it is hoped that the section may expand its coverage to several other colleges in the Virginia and Maryland areas.

▸**Service Certificates to Honor Former Officers**—The Washington Section introduced this year a plan for honoring former section officers through the presentation of Service Certificates carrying the following: "This is to certify that Mr..... has served as (office) of the Washington Section of the Institute of Aeronautical Sciences with honor and distinction and to express the appreciation of the Section for his devoted service." The certificate is signed by the Section Chairman and by the Director of the Institute. The certificates were printed for a nominal amount and appeared to be an economical and appropriate way of expressing the section's appreciation for the extensive work that must be undertaken by each group of officers in planning and executing programs for the year.

▸**Attendance Committee**—A well-organized Attendance Committee was established this year with approximately 25 key representatives located in various military and civilian agencies throughout the area. Mr. Auld sent special additional copies of each meeting notice to the committee members who, in turn, displayed these notices appropriately in their organizations. In addition, the Chairman of the committee made a telephone call a day or so prior to each meeting to remind the key representatives to contact their I.A.S. section people for dinner reservations and to make a special note of the regular section meeting. This direct mail and telephone follow-up with key people assisted greatly in maintaining a high level of attendance at each meeting.

Student Branches

Academy of Aeronautics

Five films, *East of Bombay, Farnborough Air Show, Live and Learn, Science of Flight,* and *The Lockheed P-80,* were shown at the April 9, April 23, and May 7 meetings. Chairman Nickolus Kruger presided.

The Aeronautical University, Inc.

An election of officers for the coming term was held recently with the following results: Chairman, Raymon Miller; Vice-Chairman, Lyman Welliver; Secretary, L. C. Clapper; and Treasurer, J. P. Martyr. The Faculty adviser is Alfred F. Stott.

California State Polytechnic College

On April 26, Chairman Herbert E. Pearce opened the I.A.S. Cal Poly Alumni Meeting. The speakers on this occasion were E. W. Robischon, I.A.S. Western Manager, and H. P. Hayes, Dean of Engineering, Cal Poly. R. K. Richardson, a 1950 Cal Poly aero graduate, was elected to the post of I.A.S. Alumni Manager at a meeting of Cal Poly's Aeronautical Department alumni and I.A.S. student members. Twenty-six persons were present.

On April 28, a regular meeting of the student branch was held and presided over by Chairman Pearce. Jesus C. Gomez, a senior aeronautical engineering student, presented a paper on the "Present Status of Research in Boundary Layer Control." A Ford Motor Company film, *Iron Ore to Motive Power,* concluded the meeting. Twenty-three students were in attendance.

University of California

E. C. Hallum, a member of the University of California's I.A.S. Student Branch, presented a paper on "The Hydraulic Analogy of Two-Dimensional Gas Flow," which won second prize at the West Coast Conference of I.A.S. student branches on May 17 in Los Angeles. He originally presented the paper before the San Francisco Section of the I.A.S. on April 24, where he won a first prize of $100. This latter prize was contributed by Standard Oil of California, and the presentation was made by John R. MacGregor, Associate Director, California Research Corporation of Standard Oil.

On April 11, the local branch at U.C. had an instructive and enjoyable field trip to the N.A.C.A. Ames Aeronautical Laboratory at Moffett Field. The N.A.C.A. officials were generous with their time and hospitality for the 21 student members who attended the tour of the wind tunnels and other facilities.

Case Institute of Technology

Chairman John H. Enders presided at the February 12, February 29, April 11, and May 8 meetings of this student branch. Attendance at the four meetings varied between 20 and 30 students.

A lecture on "Parachute Research" was given on February 12 by F. J. Stimler, Goodyear Aircraft Corporation. At the next meeting, films were shown depicting supersonic flight, aircraft structures, and aircraft vibrations. A field trip to Bell Aircraft Corporation in Buffalo, N. Y., was held on April 11. Concluding the spring-semester meetings was a talk given by A. O. Tischler, Head of Rocket Test Laboratory, N.A.C.A., Cleveland. Mr. Tischler's topic was "Current Problems in Rocket Research."

Cornell University

An election of officers was held at the April 30 meeting with the following results: Chairman, D. E. Ordway; Vice-Chairman, Robert Hartlieb; and Secretary-Treasurer, J. T. Corso. A film, *PBM-3 Wing Destruction Test,* concluded the meeting, which was led by Faculty Advisor Carlo Riparbelli and which was attended by 16 students.

University of Detroit

Chairman John L. Shea presided at the April 30 meeting and presented a paper on "The Application of Gas Turbines to Light Aircraft." This paper was ultimately entered in an I.A.S. Student Paper Contest. Thirteen students were present at the meeting.

University of Illinois

The final meeting of the semester was held on May 14 with 21 student members and five members of the faculty present.

An election of officers was held for the first semester of the 1952–1953 academic year. The following students were elected: Chairman, Gordon Booz; Vice-Chairman, Rex Whitehurst; and Secretary-Treasurer, Ron Arnold.

The program for the evening consisted of the I.A.S. student awards. William D. Greenfield was awarded the Scholarship Award with a certificate and a 1-year free technical membership in the I.A.S.

The competition for the I.A.S. Student Paper Award included two talks. Fred C. Hall presented "Escape Problem in Space Travel," and Wendell J. Thompson presented "Fatigue as Related to Aircraft Structures." Mr. Hall was judged the winner by the attending student officers and the faculty. His award was the same as that received by Mr. Greenfield—a certificate and a year's free Technical Membership in the I.A.S.

Indiana Technical College

Dr. Ivan Planck, Chairman, Departments of Mechanical and Aeronautical Engineering, Indiana Technical, spoke at the April 15 meeting on "The Diesel Engine vs. The Gas Turbine." A film entitled *Military Use of the Helicopter* completed the program. Chairman Harold Swallow presided; 22 students were present.

On May 13, with Chairman Swallow presiding and 19 persons present, the winner of the outstanding student award was announced as Robert L. Forbes. A lecture on "Your Future in Aeronautical Engineering" was delivered by Bennet L. Kemp, Instructor, Wind-Tunnel, Indiana Technical.

Iowa State College

At the May 7 meeting, Robert Rautenstrauch, who is studying for his M.S. degree in Aeronautical Engineering while teaching at Iowa State, gave a talk on midget racing.

The following officers were elected to serve during the coming year: Chairman, John C. Kingman; Vice-Chairman, Duane B. Schoelerman; Secretary, Lyle J. Summers; and Treasurer, Bernard C. Scott. The Honorary Chairman is C. N. Sanford, Faculty Adviser.

Kansas State College of Agriculture and Applied Sciences

An election of officers was held on May 15 with 9 students in attendance. Those elected to office are: Chairman, John Lederer; Vice-Chairman, William J. Whitesell; and Secretary-Treasurer, Marvin A. Smith. Chairman Harold Osborn presided.

North Dakota Agricultural College

At the May 20 meeting, the following officers were elected for the 1952–1953 academic year: Chairman, Donald Grommish; Vice-Chairman and Treasurer, James Marquardt; and Secretary and Council Representative, Lawrence Kummeth. Donald Flesland is Membership Chairman for the coming year. Vice-Chairman Wesley B. Martin presided; 8 students were present.

The Pennsylvania State College

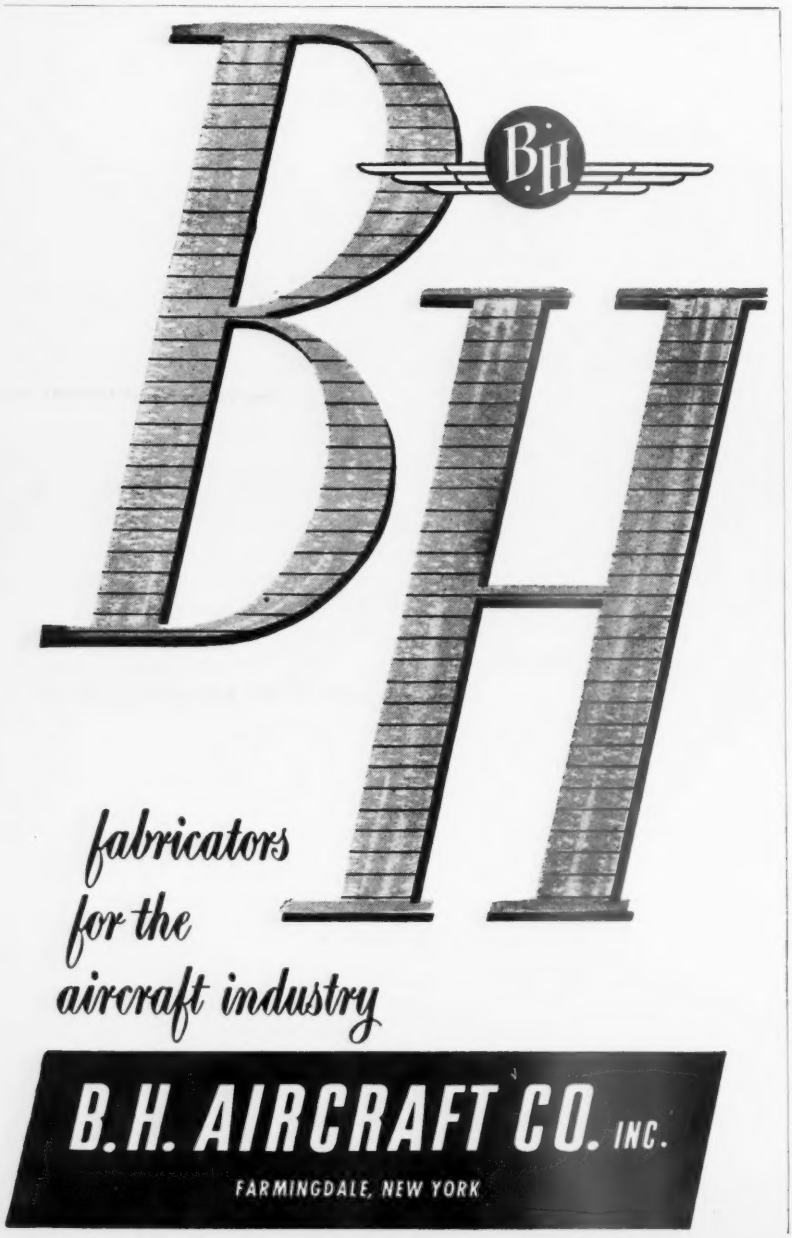
The April 23 meeting at which 40 students were present was called to order by Chairman George F. Page. An election of officers was held with the following results: Chairman, Max J. Schuster; Vice-Chairman, John W. Gaul; and Secretary-Treasurer, Frank A. Leader. After the elections were completed, student member Howard Hugh Garver, Jr., as the first participant in the I.A.S. Student Paper Contest, delivered a speech entitled "Safety Considerations in the Design and Operation of Transport Aircraft."

The University of Texas

A film, *Flight Log*, was shown at the April 21 meeting at which 21 students were present. Chairman Soren C. Jenson, Jr., presided.

Tri-State College

On April 3, the first meeting of the spring term was held, and a motion picture on *Operations Crossroad* was shown. Chairman Robert Kline presided; 25 students were present.



Members Elected

The following applicants for membership or applicants for change of previous grades have been admitted since the publication of the list in the last issue of the REVIEW.

Elected to Associate Fellow Grade

Wetmore, Joseph W., B.S. in Ae.E., Head, Gen. Aerodynamics Branch, Flight Research Div., Langley Aero. Lab., N.A.C.A.

Transferred to Associate Fellow Grade

Walter, Don L., M.S. in Ae.E., Mgr. of Engrg. & Mfg., Marquardt Aircraft Co.

Wells, Edward C., B.A., Vice-President—Engrg.; Member, Bd. of Dir., Boeing Airplane Co. (Seattle).

Elected to MEMBER Grade

Ackerman, C. A., Jr., B.S., Proj. Engr., Ryan Aero. Co.

Barton, Richard K., Pilot, Northwest Airlines.

Beach, James B., B.S.M.E. (Aero.), Group Engr., Lockheed Aircraft Corp.

Brooks, Philip D., B.S. in M.E. (A.E.), Supvr., Struct. Tech. Staff Dept., Northrop Aircraft, Inc.

Clause, Melvin, Field Serv. Engr., Consolidated Vultee Aircraft Corp. (San Diego).

Esenwein, August C., B.S., Div. Mgr., Consolidated Vultee Aircraft Corp. (Ft. Worth).

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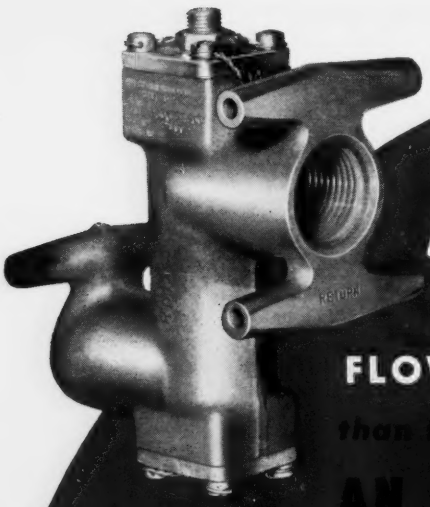

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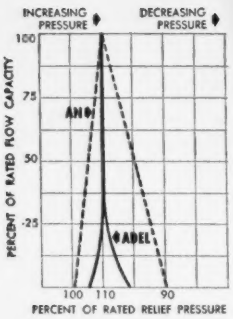

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Ferrell, Joel, Mgr., Jet Engine Branch, ARO, Inc.

Fiorio, Franco E., M.M.E., Lt. Col. & Asst. Air Attaché, Italian Embassy, Italian Air Force (Washington, D.C.).

Girard, Peter F., B.S., Chief Aerodynamicist & Engrg. Test Pilot, Ryan Aeronautical Co.

Grzedzielski, Alexander, Dr. of Engrg., Sr. Stress Engr., A. V. Roe Canada, Ltd.

Hampshire, Francis G., Sr. Design Draughtsman, British Overseas Airways Corp. (London).

Heurlin, Leonard R., B.S., Commercial Engr., General Electric Co. (River Works).

Hill, Jacques A. F., S.M., Aerodynamics Engr., Naval Supersonic Lab., Massachusetts Institute of Technology.

Jamison, David F., Jr., B.S.Ae.E., Application Engr., Aircraft Gas Turbine Div., General Electric Co. (Lockland).

Jarvis, Alvin J., Design Engr. "A," Boeing Airplane Co. (Seattle).

Johnson, Robert L., M.S., Asst. Chief, Missiles Design Sect., Douglas Aircraft Co., Inc. (Santa Monica).

Kovasznay, Leslie S. G., Dr. of Tech. Sciences, Assoc. Prof of Aeronautics, The Johns Hopkins Univ.

Luther, Marvin L., M.A., Physicist, Research Dept., Aerodynamics Branch, U.S. Naval Ordnance Test Station (Inyokern).

Madden, James E., Engrg. Designer, Rohr Aircraft Corp.

McGregor, F. Maurice, Dir. of Devel., Canadian Pacific Airlines.

Miller, Charles J., B.S. in Engrg., Mgr., Aviation Sect., General Electric Co. (Dayton).

Moss, William W., Capt., Atlantic Div., Pan American World Airways, Inc.

Peabody, E. Tilson, M. A., Mgr., General Motors Aircraft Operations, General Motors Corp. (Detroit).

Ravaud, Rene, Lt. Comdr. & Asst. Attaché, French Navy, French Embassy (Washington, D.C.).

Ryan, Raymond M., B. of Engrg. (Aero.), Design Engr., Commonwealth Aircraft Corp. Pty, Ltd. (Australia); currently assigned as Resident Rep., North American Aviation, Inc.

Schmalbeck, George L., Jr., B.S.Ae.E., Chief Admin. Engr., Globe Corp., Aircraft Div.

Silver, Alfred H., Ph.D., Tech. Engr., Aircraft Gas Turbines Div., General Electric Co. (Lockland).

Tani, Itiro, Kogakuhakushi (Advanced degree), Visiting Fellow in Aero. Engrg., Graduate School of Aero. Engrg., College of Engrg., Cornell Univ.; Prof. of Fluid Mechanics & Aerodynamics, Inst. of Science & Tech., Tokyo Univ.

Turner, James H., B.S., Lt. Comdr. & Asst. Ground Training Officer (Aerology), U.S. Naval School, All Weather Flight, U.S.N., N.A.S. (Corpus Christi).

Verba, Michael, Jr., B.S.M.E., Aerodynamicist, North American Aviation, Inc. (Los Angeles).

Weil, Howard H., B.S. in M.E., Struct. Test Engr., The Glenn L. Martin Co.

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Transferred to MEMBER Grade

Congdon, Elmer S., B.S.M.E. (Aero.), Helicopter Flight Test Engr., N.A.T.C. (Patuxent River).

Gipe, Jack R., B.S.Ae.E., Instrumentation Engr. "A," Chance Vought Aircraft Div., United Aircraft Corp. (Dallas).

Rogers, Don E., M.S.A.E., Research Engr., Combustion Group, Jet Propulsion Lab., California Institute of Technology.

Elected to Associate Member Grade

Magner, Austin P., L.L.M. (Internatl. Law), Attorney, Condon & Forsyth.

Mosbacher, David, Editor, Publisher, Managing Dir., Air Age, Inc.; Tel-Aero Assoc.

Elected to Technical Member Grade

Alcorn, Norvin E., Aerodynamicist "A," Northrop Aircraft, Inc.

Connors, Harold D., M.S.M.E., Tech. Engr., Aircraft Gas Turbine Div., General Electric Co. (Lynn).

Garlock, Ned E., B.S.A.E.E., Jr. Engr., Marquardt Aircraft Co.

Ort, Harold, B.M.E., Design Engr., General Electric Co. (Lynn).

Stasinos, Nick G., Designer-Mechanical Engr., Hughes Aircraft Co.

Thing, Charles M., B.S.E.E., Application Engr., General Electric Co. (Lynn).

Vester, John A., B.S.Ae.E., Weights Analyst, Tech. Sect., North American Aviation, Inc. (Columbus).

Transferred to Technical Member Grade

Anderson, Herbert, M.S., Lt. Col. & Pilot, U.S.A.F.

Athanasulis, Paul W., B.S. in A.T.E.

Bueker, Robert A., B.S. in Ae.E., Engrg. Draftsman, Struct. Sect., Douglas Aircraft Co., Inc. (Santa Monica).

Burgess, Robert K., B.S., Flight Research Engr., Sikorsky Aircraft Div., United Aircraft Corp.

Cantrell, Claude J., B.S.M.E. (Aero.), Research Engr., Production Research Div., Humble Oil Co.

Carpenter, Jerry, B.S.M.E. (Aero.)

Dethman, Ivan H., B.S. in Ae.E., Capt., U.S.A.F.; Aero. Engr., Wright-Patterson A.F.B.

Edstrom, Clarence R., B.S. in Ae.E., A/3C, U.S.A.F.; Proj. Engr., 6501st Support Sq., W.A.D.C., Wright-Patterson A.F.B.

French, William R., Jr. Engr., Furnishings Group, Consolidated Vultee Aircraft Corp. (San Diego).

Garver, Hugh, B.S., Research Asst., Engrg. Exp. Station, The Pennsylvania State College.

Gevarter, Sol W., B.S. in Ae.E., Aero. Research Intern, Lewis Flight Propulsion Lab., N.A.C.A.

Goldberg, Gerald L., B.S. in Ae.E., Jr. Stress Analyst, Goodyear Aircraft Corp.

Hainsworth, Thomas E., B.S., 2nd Lt., U.S.A.F.

Harmening, Wayne A., B.S. in Ae.E., Layout & Design Engr., Helicopter Div., McDonnell Aircraft Corp.

Hunter, J. Ross, B.S. (Air Transportation), Field Serv. Engr., Piasecki Helicopter Corp.

Huxhold, William J., B.S. in Ae.E., Product Engr., Western Electric Co.

Landon, Richard J., Loftsman "B," North American Aviation, Inc. (Los Angeles).

Magula, Anthony W., B.S. in Ae.E., Research Analyst "A," North American Aviation, Inc. (Downey).

Mattingly, Thomas E., Engrg. Draftsman, Northrop Aircraft, Inc.

Miller, Robert E., B.S. in Ae.E., Student & Part-time Instr., Univ. of Kansas.

Molinari, L. F., Engrg. Draftsman, North American Aviation, Inc. (Los Angeles).

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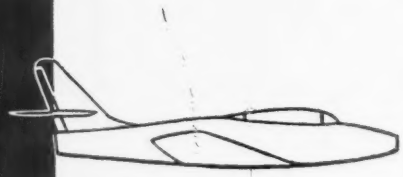

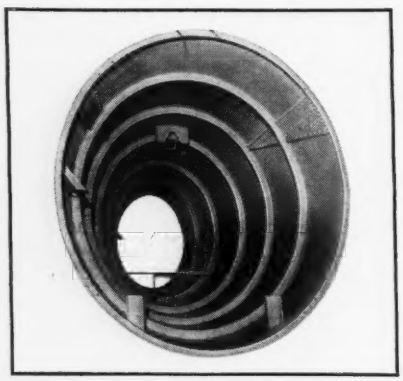

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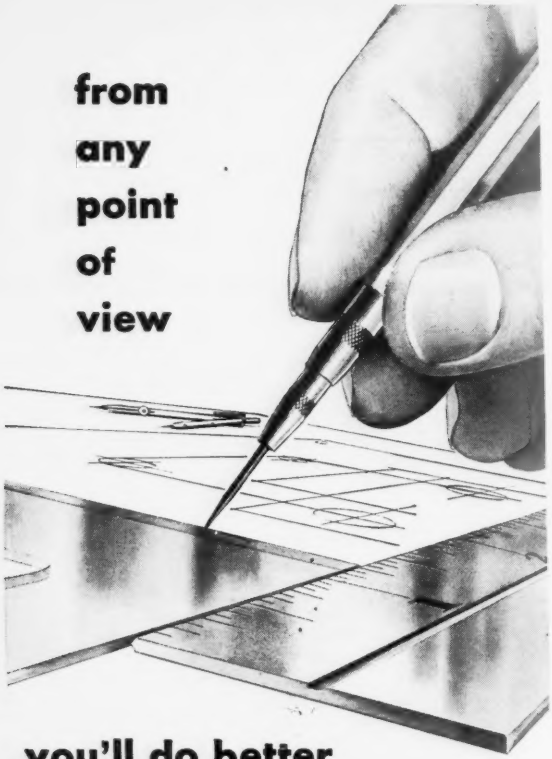

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Aerodynamics (2)

BOUNDARY LAYER & THERMOAERODYNAMICS

The Boundary Layer Fence. Wolfgang Liebe. *Interavia*, Vol. 7, No. 4, April, 1952, pp. 215–217, illus.

Aerodynamics of the boundary-layer fence; results of flight tests in Germany in 1938 on the use of the boundary-layer fence to reduce stalling on the Messerschmitt Me 109; present-day aircraft that are equipped with boundary-layer fences.

Experimental Investigation of the Turbulent-Boundary-Layer Temperature-Recovery Factor on Bodies of Revolution at Mach Numbers from 2.0 to 3.8. Howard A. Stine and Richard Scherrer. *U.S., N.A.C.A., Technical Note No. 2664*, March, 1952. 20 pp., illus. 8 references.

Readers' Forum: An Approximate Method for the Calculation of the Laminar and Turbulent Boundary Layer by Simple Quadrature for Two-Dimensional and Axially Symmetric Flow. E. Truckenbrodt. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 428, 429, illus. 10 references.

Critical Study of Integral Methods in Compressible Laminar Boundary Layers. Paul A. Libby, Morris Morduchow, and Martin Bloom. *U.S., N.A.C.A., Technical Note No. 2655*, March, 1952. 40 pp., illus. 24 references.

Comparison of the amount of calculation and accuracy of results of some integral methods of obtaining boundary-layer characteristics to determine which method gave the required data most accurately and most conveniently. The methods considered were: the one-parameter von Kármán-Pohlhausen method, with three different assumptions for the velocity profiles, and the two-parameter method, with two different assumptions for the velocity profiles.

Laminar Boundary Layer over Flat Plate in a Flow Having Circular Streamlines. Artur Mager and Arthur G. Hansen. *U.S., N.A.C.A., Technical Note No. 2658*, March, 1952. 28 pp., illus. 15 references.

An investigation of laminar-boundary-layer development over a semi-infinite plate in a flow with concentric circular streamlines with the limitation of small total turning of the main stream flow. The study was undertaken to demonstrate the influence of viscosity and compressibility on the secondary flow in relatively thin boundary layers.

The Structure of the Turbulent Boundary Layer. A. A. Townsend. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 2, April, 1951, pp. 375–395, illus. 13 references.

Investigation of the turbulent motion in a boundary layer with zero pressure gradient, using hot-wire anemometers to measure the intensities of the velocity components, shear stresses, and other turbulent boundary-layer characteristics.

Analysis of Turbulent Free-Convection Boundary Layer on Flat Plate. E. R. G. Eckert and Thomas W. Jackson. (*U.S., N.A.C.A., Technical Note No. 2207*, 1950.) *U.S., N.A.C.A., Report No. 1015*, 1951. 7 pp., illus. 9 references. Superintendent of Documents, Washington. $0.15.

FLUID MECHANICS & AERODYNAMIC THEORY

Slow Motion of Viscous Liquid Near a Half-Pitot Tube. W. R. Dean. *Cambridge Philosophical Society, Proceedings*, Vol. 48, Part 1, January, 1952, pp. 147–167, illus. 6 references. An experimental investigation in which half-pitot tubes were used to measure two-dimensional fluid velocities as near as possible to a fixed boundary.

On Boltzmann's Equation in the Kinetic Theory of Gases. E. Wild. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 3, July, 1951, pp. 602–609. 2 references.

On the Propagation of Disturbances from Moving Sources. A. G. Walters. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 1, January, 1951, pp. 109–126, illus. 8 references.

Green's vibrational functions are used to obtain a general expression for the disturbance from a point source. From the expression the potential due to transient sources of sound moving with subsonic and supersonic velocities is derived.

Application of Transonic Similarity. Adolf Busemann. *U.S., N.A.C.A., Technical Note No. 2687*, April, 1952. 22 pp., illus.

Summary of the important points of the background of transonic similarity in quasi-two-dimensional flow in order to stabilize the variation of opinion concerning its applications. The appendix covers the application of transonic similarity to axisymmetric bodies.

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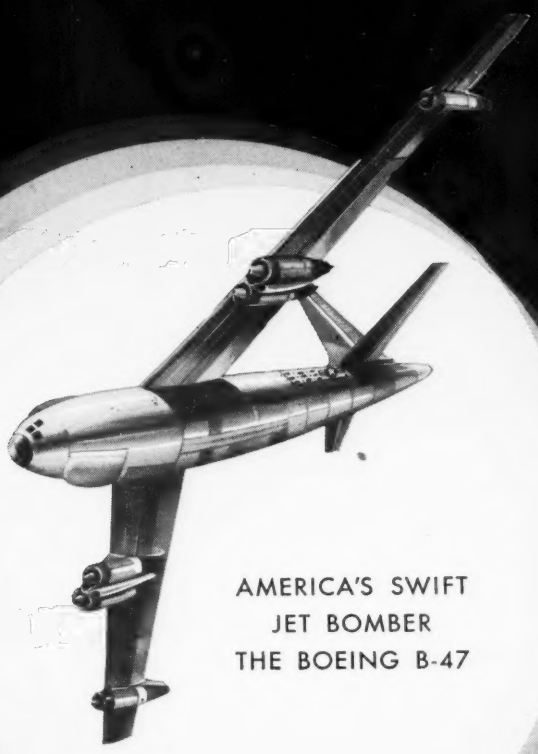

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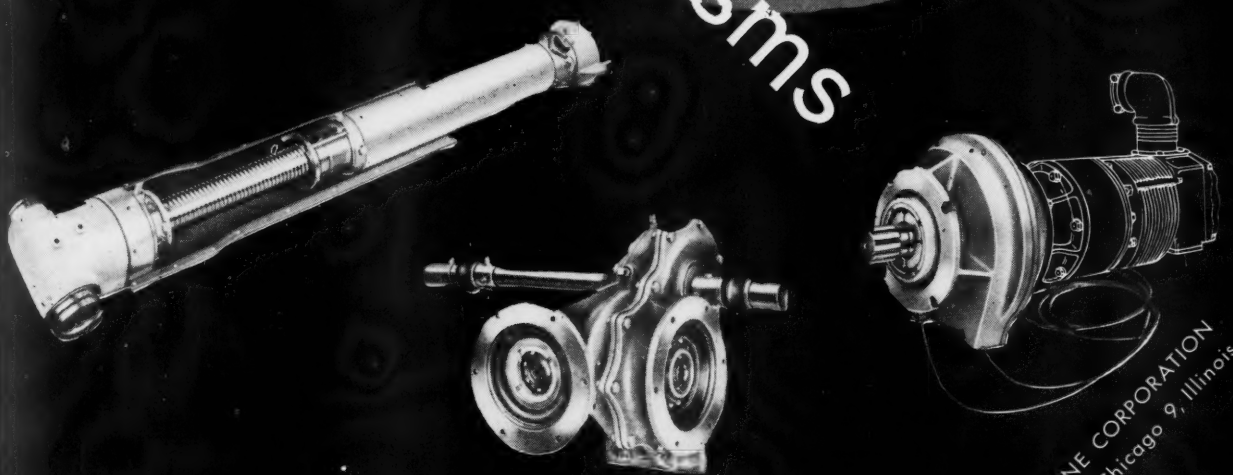

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Readers' Forum: On the Stability of Plane Parallel Laminar Flows to Two- and Three-Dimensional Disturbances. Martin Lessen. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 431, 432. 2 references.

On the Slow Motion of a Sphere Along the Axis of a Rotating Fluid. K. Stewartson. *Cambridge Philosophical Society, Proceedings*, Vol. 48, Part 1, January, 1952, pp. 168–177. 5 references.

The General Motion of a Sphere in a Viscous Liquid. M. P. Drazin. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 1, January, 1951, pp. 142–145. 1 reference.

Two-Dimensional Subsonic Flow past Elliptic Cylinder by the Variational Method. G. V. Rao. *U.S., N.A.C.A., Technical Note No. 2666*, March, 1952. 39 pp., illus. 14 references.

The Similarity Law for Nonsteady Hypersonic Flows and Requirements for the Dynamical Similarity of Related Bodies in Free Flight. Frank M. Hamaker and Thomas J. Wong. *U.S., N.A.C.A., Technical Note No. 2631*, February, 1952. 24 pp., illus. 4 references.

A Solution of the Navier-Stokes Equation for Source and Sink Flows of a Viscous Heat-Conducting Compressible Fluid. Robert V. Hess. *U.S., N.A.C.A., Technical Note No. 2630*, February, 1952. 60 pp., illus., folding charts. 24 references.

Wave Reflexion Near a Wall. A. Robinson. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 3, July, 1951, pp. 528–544, illus. 7 references.

Analysis of the reflection of a shock or expansion wave near a rigid wall, considering any arbitrary velocity profile that varies from zero at the wall to a constant supersonic velocity in the main stream.

A Note on the Correspondence Between the *x,t*-Plane and the Characteristic Plane in a Problem of Interaction of Plane Waves of Finite Amplitude. P. M. Stocker and R. E. Meyer. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 3, July, 1951, pp. 518–527, illus. 6 references. Analysis of the head-on interaction, in the one-dimensional unsteady isentropic flow of a perfect gas, of a simple shock and a simple expansion wave.

On the Interaction Between Shock Waves and Boundary Layers. K. Stewartson. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 3, July, 1951, pp. 545–553. 9 references.

Readers' Forum: Diffraction of Blasts by Axisymmetric Bodies. H. F. Ludloff and M. B. Friedman. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 425, 426, illus. 2 references.

Generalized Linearized Conical Flow. W. D. Hayes, R. C. Roberts, and N. Haaser. *U.S., N.A.C.A., Technical Note No. 2667*, March, 1952. 48 pp., illus. 11 references. Development of the basic theory of generalized linearized conical flow; some aerodynamic applications of the theory.

Supersonic Conical Flow. Stephen H. Maslen. *U.S., N.A.C.A., Technical Note No. 2651*, March, 1952. 32 pp., illus. 24 references. A method for the solution of the nonlinear equations for supersonic conical flow. The solution is mostly numerical, using the methods of characteristics and relaxation.

Transonic Flow Past Finite Wedges. A. G. Mackie and D. C. Pack. *Cambridge Philosophical Society, Proceedings*, Vol. 48, Part 1, January, 1952, pp. 178–187. 12 references.

A physically possible solution for the two-dimensional flow of an infinite stream, subsonic at infinity, past infinitely long wedges of finite sloping edge is obtained directly from the generalized solution arrived at by the hodograph method.

Pressure Fluctuations in Isotropic Turbulence. G. K. Batchelor. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 2, April, 1951, pp. 359–374, illus. 16 references.

Development of a formal expression for the correlation $P(r)$ between the fluctuating pressures at two different points distance r apart in a field of homogeneous isotropic turbulence. The pressure correlation function at large Reynolds Numbers of turbulence is worked out in detail.

On the Law of Decay of Homogeneous Isotropic Turbulence and the Theories of the Equilibrium and Similarity Spectra. S. Goldstein. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 3, July, 1951, pp. 554–573. 21 references.

Triple Velocity Correlations in Isotropic Turbulence. R. W. Stewart. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 1, January, 1951, pp. 146–157, illus. 11 references.

Measurement of the triple velocity correlation, using an electronic circuit based on Townsend's triple correlation, of the turbulence produced by the insertion of a square-mesh grid at the beginning of the wind-tunnel working section over a range of Reynolds Numbers covering most of the initial period of the decay of turbulence.

A Comparison of Heisenberg's Spectrum of Turbulence with Experiment. Ian Proudman. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 1, January, 1951, pp. 158–176, illus. 13 references.

INTERNAL FLOW

Application of a Channel Design Method to High-Solidity Cascades and Tests of an Impulse Cascade with 90° of Turning. John D. Stanitz and Leonard J. Sheldrake. *U.S., N.A.C.A., Technical Note No. 2652*, March, 1952. 65 pp., illus. 16 references.

Experimental Investigation of a 90° Cascade Diffusing Bend with an Area Ratio of 1.45:1 and with Several Inlet Boundary Layers. Daniel Friedman and Willard R. Westphal. *U.S., N.A.C.A., Technical Note No. 2668*, April, 1952. 30 pp., illus. 5 references.

Three-Dimensional Flow in Axial Compressors. J. R. Schnitger. (*Teknisk Tidskrift*, Vol. 81, No. 46, December 15, 1951, pp. 1087–1089.) *Engineers' Digest*, Vol. 12, No. 3, March, 1952, pp. 89, 90, illus. Application of the vortex-field and radial-equilibrium theories to determining the three-dimensional flow characteristics in axial compressors.

A Technique Applicable to the Aerodynamic Design of Inducer-Type Multistage Axial-Flow Compressors. Melvyn Savage and Loren A. Beatty. *U.S., N.A.C.A., Technical Note No. 2598*, March, 1952. 62 pp., illus. 9 references.

Effect of Mach Number on the Flow and Application of Compressibility Corrections in a Two-Dimensional Subsonic-Transonic Compressor Cascade Having Varied Porous-Wall Suction at the Blade Tips. William B. Briggs. *U.S., N.A.C.A., Technical Note No. 2649*, March, 1952. 43 pp., illus. 5 references.

Analytical Investigation of Some Three-Dimensional Flow Problems in Turbomachines. Frank E. Marble and Irving Michelson. *U.S., N.A.C.A., Technical Note No. 2614*, March, 1952. 109 pp., illus. 29 references.

Theoretical investigation of the flow of an incompressible inviscid fluid through a turbomachine with blade rows consisting of an infinite number of similar infinitely thin blades which was undertaken to examine the three-dimensional flow phenomena and to illustrate the methods of calculation.

Two-Dimensional Losses in Turbine Blades. Charles A. MacGregor. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June 1952, pp. 404–408, 432, illus.

Results of tests on three turbine blades of different design characteristics in a two-dimensional cascade tunnel at varying angles of attack, stagger angles, and solidity at $M = 0.4$ and $R = 6.5 \times 10^5$. Calculations of the boundary-layer loss, based on the measured pressure distributions, are compared with test data.

Slow Motion of Viscous Liquid in a Semi-Infinite Channel. W. R. Dean. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 1, January, 1951, pp. 127–141, illus. 4 references.

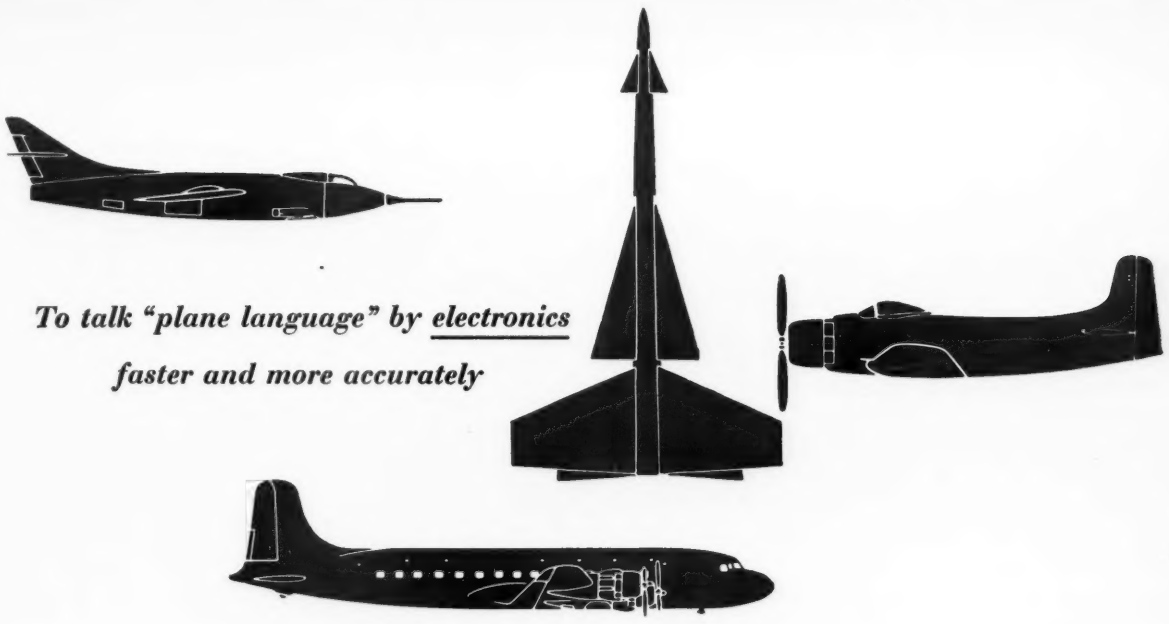
Concerning the Flow About Ring-Shaped Cowlings. VIII—Further Measurements on Annular Profiles. Dietrich Küchemann and Johanna Weber. (*ZWB, Forschungsbericht, No. 1236/8*, March 25, 1943.) *U.S., N.A.C.A., Technical Memorandum No. 1328*, February, 1952. 11 pp., illus. 4 references.

Readers' Forum: Comments on "Supersonic Flow of a Two-Dimensional Jet" by S. I. Pai. E. B. Klunker and Keith C. Harder. **Author's Reply.** *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 427, 428. 1 reference.

Readers' Forum: Effect of Wind-Tunnel Nozzle on Steady-Flow Nonuniformities. H. S. Ribner and M. Tucker. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 426, 427, illus. 3 references. Analysis of the turbulence carried by the wind-tunnel stream, using the spectrum concept, and including the effects of the compressibility of the flow.

NATURAL FLIGHT

Flight and Natation. I. Denys Jones. *Sailplane and Glider*, Vol. 20, No. 3, March, 1952, pp. 2–6, illus. Comparison of the action of a simple two-bladed propeller with the wing action of birds.



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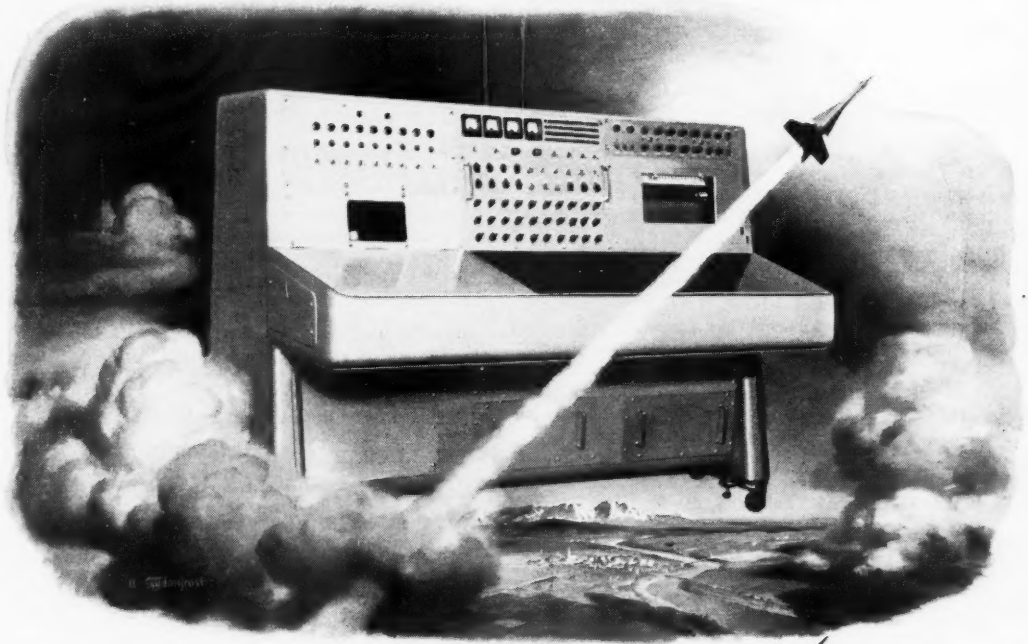

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Problems of Transonic Flight. A. N. Clifton. *Royal Aeronautical Society, Journal*, Vol. 56, No. 495, March, 1952, pp. 155–171, illus.

An analysis of the problems of drag and thrust, stability and control, and temperature effects and their application to the aerodynamic design of fighter and other military aircraft that fly in the transonic region.

STABILITY & CONTROL

A Description and a Comparison of Certain Nonlinear Curve-Fitting Techniques, with Applications to the Analysis of Transient-Response Data. Marvin Shinbrot. *U.S., N.A.C.A., Technical Note No. 2622*, February, 1952. 41 pp., illus., tables. 10 references.

Explanation of several least-squares methods of curve-fitting a set of data to a nonlinear function; the methods are each applied to fit flight data to a sum of two exponentials to illustrate their use in calculating aircraft stability parameters.

Calculation of the Lateral-Dynamic Stability of Aircraft. A. Raikh. (*Moscow, Tsentral'nyi Aero-Girodinamicheskii Institut, Trudy, No. 453*, 1939.) *U.S., N.A.C.A., Technical Memorandum No. 1264*, February, 1952. 82 pp., illus. 14 references.

WINGS & AIRFOILS

High-Speed Subsonic Characteristics of 16 NACA 6-Series Airfoil Sections. Milton D. Van Dyke. *U.S., N.A.C.A., Technical Note No. 2670*, March, 1952. 65 pp., illus. 10 references.

General Reverse Flow and Variational Theorems in Lifting-Surface Theory. A. H. Flax. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 361–374, illus. 25 references.

Presentation of a general form of the relationship between the characteristics of wings in direct and reverse flows which is applicable, within the limits of linearized lifting surface theory, to wings of any plan form in subsonic or supersonic flows.

Readers' Forum: On an Extension of Slender-Wing Theory. Mac C. Adams and W. R. Sears. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 424, 425, illus. 4 references. Extension of the slender-wing theory of Munk and Jones to cover thin wings in supersonic steady flow.

Readers' Forum: On the General Solution for Unsteady Motion of a Rectangular Wing in Supersonic Flow. John W. Miles. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 421, 422. 8 references.

Aeroelasticity

Charts and Approximate Formulas for the Estimation of Aeroelastic Effects on the Loading of Swept and Unswept Wings. Franklin W. Diederich and Kenneth A. Foss. *U.S., N.A.C.A., Technical Note No. 2608*, February, 1952. 98 pp., illus. 8 references.

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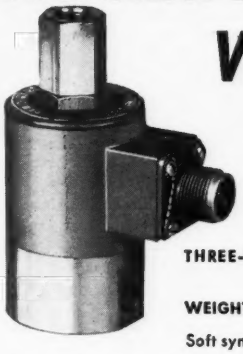

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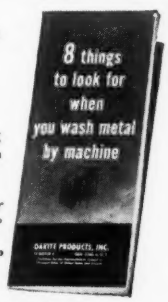

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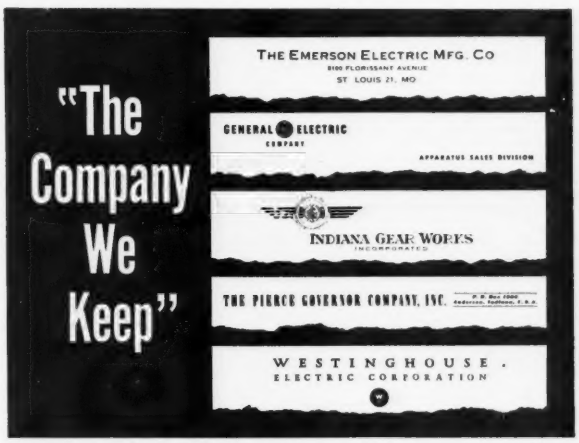

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Construction and performance of the Ferranti digital computer Mark 1 that contains 3,500 tubes, twelve cathode-ray-tube stores, and a magnetic drum storing 16,000 twelve-digit numbers. Problems can be put into the machine by teleprinter tape at the rate of 200 decimal digits per sec.; results are printed on a standard teleprinter.

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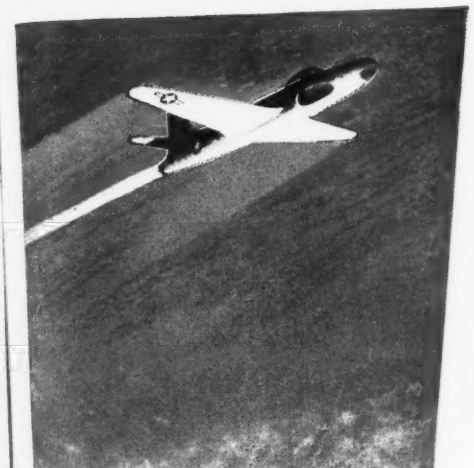

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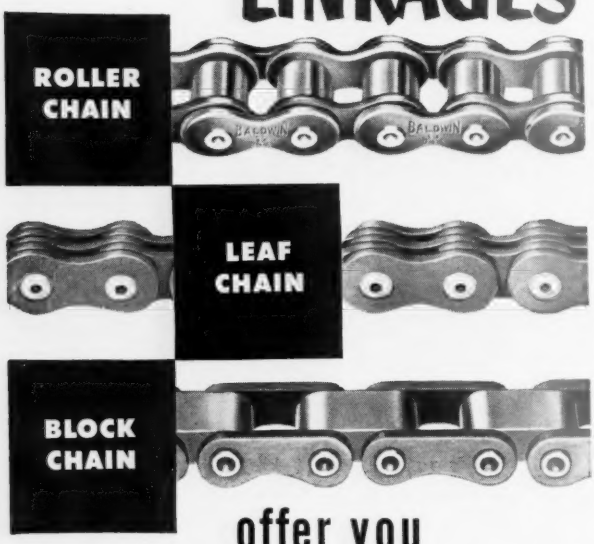

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Development of a graphical method in which straight-line methods for the solution of network problems are applied to the analysis and design of image-parameter and insertion-parameter filters.

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Construction and application of printed circuit pack units, each containing up to six resistors and capacitors preconnected into a desired circuit, developed by the Stupakoff Ceramic and Manufacturing Co.

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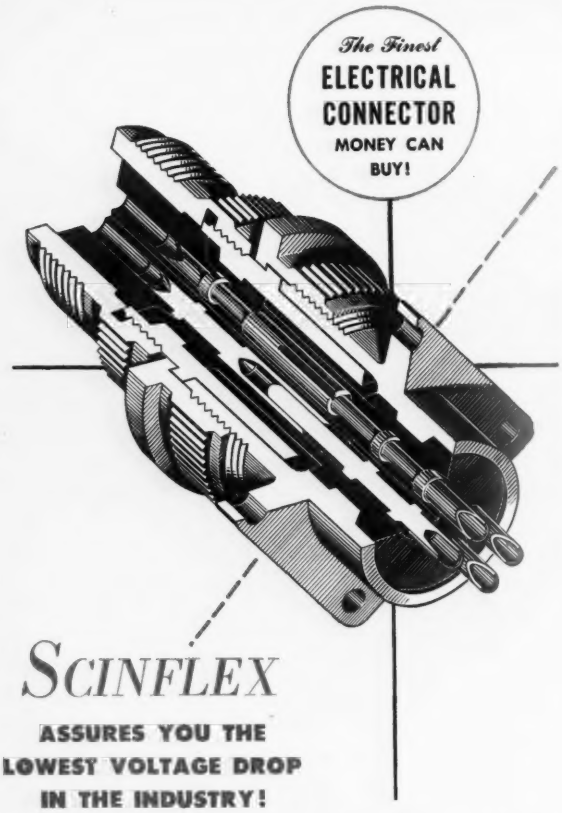

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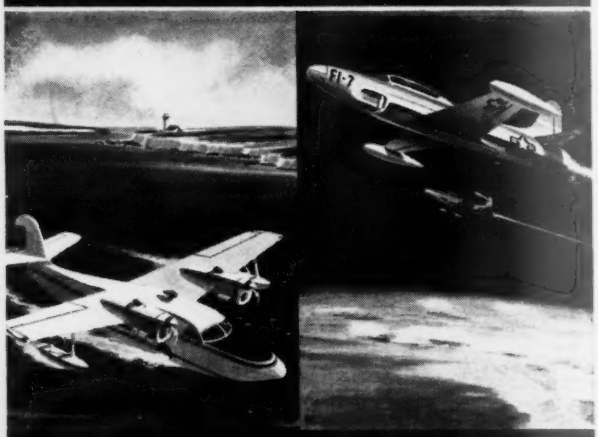

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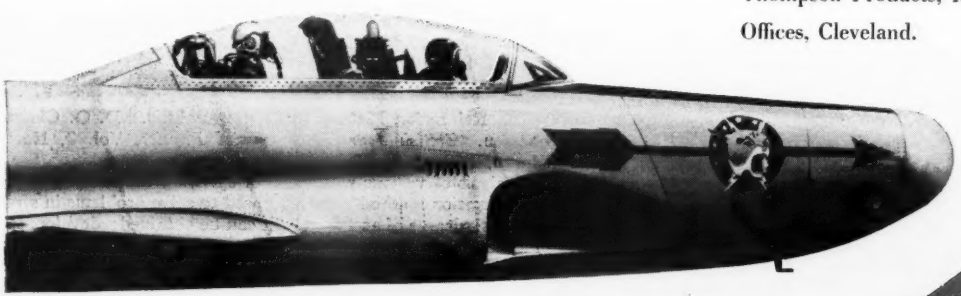

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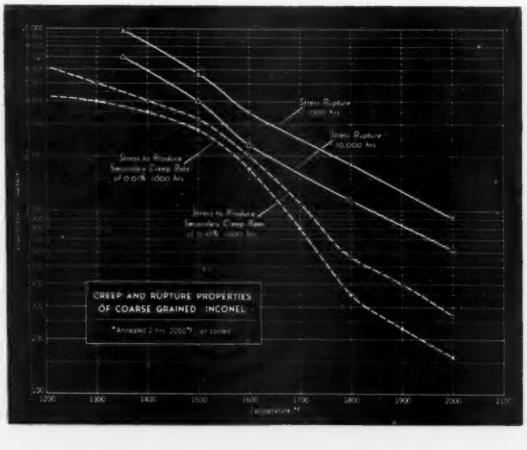

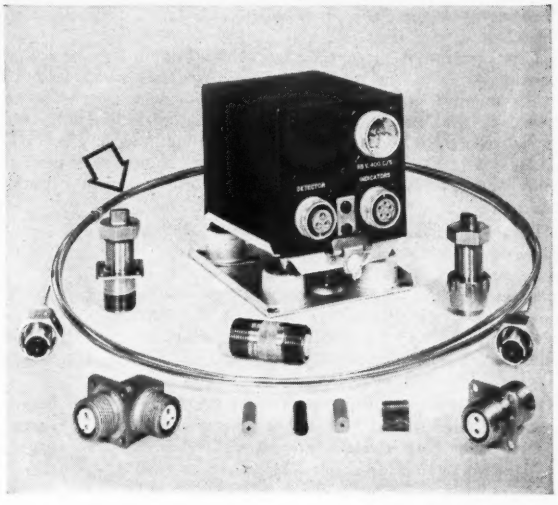

FINDS FIRE – and survives it. Heart of this new electronic fire detector for aircraft is its Inconel sensing unit (arrow). The slim and extremely ductile Inconel tube contains two fine Inconel wires, encased within a thermistor ceramic. Heat from fire raises temperature of ceramic, lowering its electrical resistance. Detector circuit then actuates the signal. During controlled experiments, one of these Inconel units successfully withstood over 100 fire tests. *Photo courtesy of Walter Kidde & Company, Inc., Belleville, N. J.*

may break out, the Inconel element – even after long exposure to high temperatures – retains high strength and ductility. It not only functions efficiently at -65° F., but resists fire damage when temperatures soar to 2000°. This helps the unit automatically reset and go back to work after a fire is out.

There's another characteristic of Inconel that's important, too – *workability*. With Inconel, you needn't worry about running into fabrication problems. Inconel is readily machinable with high-speed steel tools, and can be joined by the usual welding, brazing and soldering processes common to industry.

You'll find complete information about this useful high-temperature alloy in our 24-page reference manual, "Engineering Properties of Inconel." Your copy is waiting. Just write and ask for Technical Bulletin T-7.

One last – and important – point. Inconel, like other nickel alloys, is now on extended delivery because of defense needs. So it is necessary to include NPA rating and complete end-use information with all orders.

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Technical Note No. 2640, March, 1952. 110 pp., illus. 21 references.

Development of the exact theory for determining the actual buckling stress $\sigma_{cr.}$ of arbitrary plate assemblies which leads to transcendental buckling conditions for $\sigma_{cr.}$ which have to be solved by trial and error; derivation of design formulas for the individual buckling stresses and for a column with T-section. Results of stress-strain tests on square tube columns were used in column tests to study the interaction of local and column buckling.

Ripple-Type Buckling of Sandwich Columns. A. Cemal Eringen. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 409–417, illus. 17 references.

Analysis of the problem of ripple-type buckling of thick sandwich columns having orthotropic cores under axial compressive loads and under end moments. The method can be applied to general end conditions and for arbitrary axial and transverse loading.

Readers' Forum: Comments "On the Deflection of Swept Cantilevered Surfaces" by C. Martin and Hemen J. Gursahaney. David B. Hall. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 423, 424, illus.

The Buckling Stress of Thin Cylindrical Shell Under Axial Compressive Load, Forming Axial-Symmetrical Deformation. Masatsugu Kuranishi. *Japan Society for Applied Mechanics, Journal*, Vol. 3, No. 18, August, 1950, pp. 19–24, illus. 3 references.

Some Notes on the Plastic Deformation of Hollow Spheres with Large Strain. Hisao Mii. *Japan Society for Applied Mechanics*, Vol. 3, No. 18, August, 1950, pp. 13–19, illus. 4 references.

Derivation of stress expressions in the form of definite integrals for the problem of plastic deformations of thick-walled light metal spheres subjected to internal and external pressures.

A Problem in Dynamic Plasticity: The Enlargement of a Circular Hole in a Flat Sheet. W. Freiberger. *Cambridge Philosophical Society, Proceedings*, Vol. 48, Part 1, January, 1952, pp. 135–148, illus. 5 references.

Buckling of Oblique Plates with Clamped Edges Under Uniform Compression. W. H. Wittrick. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 182*, November, 1951. 23 pp., illus., folding charts. 6 references.

Analysis of the buckling of flat oblique plates with all edges clamped. A procedure is developed, using a Rayleigh-Ritz energy method, for obtaining numerical values of the critical stresses; calculations for the buckling stress coefficient are obtained for plates having acute angles of 60° and 45°, and side ratios varying between $^3/_5$ and $^5/_3$.

Experimental Diagrams of Deformation and Strain Distribution in Curved Plates Under Compression. K. B. Jackson and A. H. Hall. *Canada, National Research Council, Aeronautical Report No. AR-9*, 1951. 149 pp., illus. 2 references.

Stress-strain diagrams of strain distribution and plate deformations for values of edge strain between zero and failure are presented for twenty representative plates covering a range of width-to-thickness ratio from 77 to 400, and ratios of plate thickness-to-radius of curvature from 0 to 1.6×10^{-3}.

Correlation Between Some Stability Problems for Orthotropic and Isotropic Plates Under Biaxial and Uniaxial Direct Stress. W. H. Wittrick. *Australia, Department of Supply, Aeronautical Research Laboratories, Report No. SM. 184*, December, 1951. 18 pp., illus. 2 references.

Investigation of Stress Distribution in Rectangular Plates with Longitudinal Stiffeners Under Axial Compression After Buckling. Chi-Teh Wang and Harry Zuckerberg. *U.S., N.A.C.A., Technical Note No. 2671*, March, 1952. 61 pp., illus. 5 references.

(*Concluded on page 110*)

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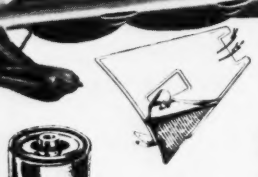

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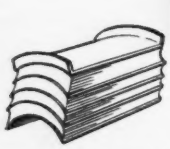

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Aeronautical Reviews — BOOKS

Book Notes

COMPUTERS

Electronic Analog Computers (D-C Analog Computers). Granino A. Korn and Theresa M. Korn. New York, McGraw-Hill Book Company, Inc., 1952. 378 pp., illus., diagrs., figs. $7.00.

The present volume is intended primarily as a textbook on the design and operation of d.c. analog computers. The explanations and data are illustrated by examples from industrial applications, including design of automatic pilots and linear and nonlinear servomechanisms, and solutions of oscillation problems, ballistic trajectories, and aircraft flight equations. Samples of problem-preparation records are given. No mathematics beyond that taught in an elementary course on differential equations is required to read the book. A knowledge of electronics is prerequisite, and the authors refer the reader to elementary texts on this subject.

Chapter 1 briefly treats of the applications of computing devices, the mathematical relations involved, and the techniques used. In Chapter 2 is presented a simple standard procedure for setting up a d.c. analog computer to solve a given set of differential equations. Chapter 3 gives computer setups for a number of practical problems that are illustrations of modern industrial applications. Stress is laid on the preparation of useful records of each computation. Chapters 4 to 6 are concerned with the theory and design of linear computing elements, operational amplifiers and networks; d.c. amplifiers for computer applications and developments in the fields of analog multiplication and function generation. Chapter 7 describes the design of auxiliary circuits, such as power supplies and recorders. Two sections are devoted to improved control circuits; procedures for operating and checking d.c. analog computers are covered here. The design and construction of complete computer installations form the chief topics of Chapter 8. Reliable and economical operation is emphasized in a discussion of the choice of computing elements and associated equipment. Some modern installations are described in detail and are discussed in the light of design principles previously presented. The volume recounts some of the experiences of many workers and laboratories concerned with the design and application of analog computers. Many current diagrams of actual equipment have been reproduced. The appendix stresses some properties of parallel-feedback-type operational amplifiers. The 4-page bibliography is supplemented by numerous footnote references. There are an index of authors and an index of subjects. Granino A. Korn is a Staff Engineer, Lockheed Aircraft Corporation.

EQUIPMENT

HYDRAULIC

Proceedings of the 7th National Conference on Industrial Hydraulics, November 7–8, 1951; Sponsored by the Graduate School and Armour Research Foundation, Illinois Institute of Technology. (Conference Series, Vol. 5) Chicago, January, 1951. 202 pp., illus., diagrs., figs. $4.50.

Partial Contents: Low Temperature Hydraulic Fluids, J. B. Shipp, Jr. Flow Testing of Centrifugal Pump Components Using Air as a Medium, A. J. Thompson. Reverse Rotation Operation for Pumps, W. M. Swanson. Control of Leakage in Taper Pipe Thread Joints, Douglas McConnell. Hydraulic Hose Design, J. J. Millard. The Growth and Application of the Accumulator in Industrial Hydraulic Systems, Edward M. Greer.

FUELS & LUBRICANTS

Fuels and Combustion. Marion L. Smith and Karl W. Stinson. New York, McGraw-Hill Book Company, Inc., 1952. 340 pp., illus., diagrs., figs. $6.50.

This textbook has been written to present to undergraduate students and to engineers fundamental and factual information about solid, liquid, and gaseous fuels and the problems associated with their combustion. The general topics of fuel technology and the relationships of air, fuel, combustion products, and the heat released are presented. Fundamental concepts of modern theories of combustion are covered in such a manner that they are within the grasp of students who are not chemistry majors.

Chapters 1 to 7 treat of the types of fuels, stoichiometric and thermochemical analysis, the combustion process, physical properties of fuels, gas and oil burners, and coal-burning equipment. Problems of reciprocating internal-combustion engines, gas turbines, and rocket motors are discussed in Chapter 8. The book concludes with an appendix giving charts dealing with combustion phenomena and with a subject index. Problems and references to current literature appear at the end of each chapter. The authors are Assistant Professor and Professor of Mechanical Engineering, The Ohio State University, in the order given above.

Methods of Analysis of Fuels and Oils. J. R. Campbell. Edited by William Gibb. New York, Chemical Publishing Company, Inc., 1952. 216 pp., diagrs., figs. $4.00.

The object of this book is to provide a laboratory guide to the principal methods of examination of gaseous, liquid, and solid fuels and lubricating oils. It is designed to meet the requirements of students of applied chemistry, metallurgy, and engineering and comprises essentially a collection of established experimental methods. These methods constitute the basis of the courses in practical training in the testing of fuels given in the Royal Technical College, Glasgow, where the author was associated with the Department of Technical Chemistry. Brief résumés of the theoretical principals underlying the methods have been included in a number of instances. A short bibliography of 28 references is given. Over 58 drawings of test equipment are reproduced.

Contents: (1) Proximate Analysis of Coal. (2) Ultimate Analysis of Coal. (3) Determination of Some of the Minor Constituents of Coal. (4) Determination of the Calorific Value of Coal. (5) Calculation of the Mineral Matter Content of Coal. (6) Assay of Coal for Carbonisation Purposes. (7) Coal Cleaning and Washability Curves. (8) Examination of Oils. (9) Gas Analysis. (10) Calorific Value of Gases. (11) High Temperature Measurement. Bibliography. Appendix (Conversion Factors, Vapour Pressure of Water, Logarithms). Index.

INSTRUMENTS

Automatic and Manual Control. Papers Contributed to the Conference Organized by the Department of Scientific and Industrial Research and Held at the College of Aeronautics, Cranfield, July 16–21, 1951. A. Tustin, Chairman, Editorial Committee. London, Butterworths Scientific Publications, 1952. 584 pp., illus., diagrs., figs. 50s.

Contents: Presidential Address, Ben Lock speiser. Section 1, Educational Problems: Feedback System Engineering—A Challenging Educational Objective, Gordon S. Brown. Education in Relation to Automatic Control. Section 2, General Theory: The Stability Criterion, L. S. Dzung. Relative Damping as Criterion for Stability and as an Aid in Finding the Roots of a Hurwitz Polynomial, A. Leonhard. The Development of Relationships Concerning the Frequency Bandwidth and the Mean Square Error of Servo-Systems from Properties of Gain-Frequency Characteristics, J. H. Westcott. Some Aspects of the Problem of Optimizing the Performance of Servo-Systems Incorporating Rotary Generators, J. M. Layton. The Application of the Electrolytic Tank to Servo-Mechanism Design, A. R. Boothroyd and J. H. Westcott. A Generalization of the Frequency Response Method for the Study of Feedback Control Systems, N. L. Kusters and W. J. M. Moore. Application of Statistical Techniques to the Servo-Mechanism Field, M. J. Pélegrin. The Determination of the Best Form of Response for a Servo When an Extraneous Random Disturbance Is Present with an Error Signal, S. Jones. Section 3, Process Control: Steady-State Systems Engineering in Automatic Process Control, H. Tyler Marcy and M. Yachter. The Scope for the

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Further Application of Servo Theory in Process Control, N. Ream. The Characteristics of Air-Operated Controllers, A. R. Aikman and C. I. Rutherford. Analysis of Pneumatic Controllers, J. M. L. Janssen. The Influence of Measuring and Transmission Lags, A. R. Aikman. Some Recent Developments in Process Control, W. H. Howe. Transfer Function Analysis of Heat Exchange Processes, Y. Takahashi. Discussion on Process Control. Section 4, Non-Linear Problems: An Introduction to the Analysis of Non-linear Closed Cycle Control Systems, W. E. Scott. Some New Concepts and Theorems Concerning Non-Linear Systems, E. Colin Cherry and W. Millar. A General Linearizing Process for Non-Linear Control Systems, J. M. Loeb. The Stabilization of On-Off Controlled Servo-Mechanisms, A. M. Uttley and P. H. Hammond. Non-Linear Control Systems, N. Minorsky. Stability Criteria for Certain Non-Linear Systems, R. W. Jones. The Jerking Motion Caused by Static Friction in Position Control Systems, J. D. Harmer. Backlash and Resilience Within the Closed Loop of Automatic Control Systems, J. R. Liversidge. Section 5, Systems Working on Intermittent Data and Step-by-Step Servos: Characteristics of Sampling Sero-Systems, C. Holt Smith, D. Lawden, and A. E. Bailey. Application of Finite Difference Operators to Linear Systems, B. M. Brown. Deviation Dependent Step-by-Step Control Systems and Their Stability, Hans Sartorius. Deviation Dependent Step-by-Step Control as Means to Achieve Optimum Control for Plants with Large Distance-Velocity Lag, R. C. Oldenbourg. Oscillatory Phenomena in On-Off Controls with Feed-Back, W. Oppelt. Section 6, The Human Operator: Free-Moving Versus Fixed Control Levers in a Manual Tracking Task, C. B. Gibbs and J. C. Baker. The Human Transfer Function in Servo-Systems, J. D. North. Section 7, Particular Devices and Applications Including Analogues: Electro-Hydraulic Control of Water Turbines, A. Garde. Symposium on Analogue Computers. Section 8, Analysis of the Behaviour of Economic Systems. Section 9, Demonstrations at the Conference. Mathematical Note on the Theory of the Complex Variable. Author Index. Subject Index.

Electrical Measurements. Forest K. Harris. New York, John Wiley & Sons, Inc., 1952. 784 pp., figs., illus. $8.00.

This book is the outgrowth of lectures on electrical measurements given to students of electrical engineering and physics by the author, who is Professional Lecturer in Electrical Engineering at the George Washington University, and Physicist at the National Bureau of Standards. The points of view of the practicing engineer, laboratory worker, research worker, and student are combined in this study of basic electrical instrument theory, application methods, apparatus, and techniques. The scope of the volume ranges from basic principles to applications within the field of d.c. and low-frequency oscillations. The author discusses the origins, relations, and dimensions of electrical units and then systematically presents the basic theory of the various types of electrical instruments. Particular stress is placed on the suitability of specific techniques and instruments for laboratory work, good operating techniques, and error detection and compensation. Prerequisite for a worthwhile study of the work are a good acquaintance with the theory of electricity and of electric circuits, a background of mathematics through calculus, and laboratory experience in the manipulation of electrical instruments and apparatus. Footnote references are frequent, and there is a combined index of authors and topics.

MACHINE ELEMENTS

FASTENINGS

Bolt, Nut and Rivet Standards. 2nd Ed. Cleveland, Industrial Fasteners Institute, 1952. 247 pp., diagrs. $3.00.

This compilation of commercial standards is published both to aid production in manufac-

turers' plants and to acquaint users with accepted standards of nomenclature, dimensions, sizes, and other practices. Many of the standards presented have been developed and approved through the procedure of organizations, such as the American Standards Association and the Division of Simplified Practice of the U.S. Department of Commerce, with the participation of manufacturers; acknowledgment is made in each case. The remainder of the standards has been prepared by the Industrial Fasteners Institute with the cooperation of users and both member and nonmember manufacturers. The previous edition of this compilation was published in 1941. The first two-thirds of the book presents standards for square and hexagon bolts and nuts, round head bolts, track bolts, plow bolts, studs, miscellaneous bolts, slotted and recessed head screws, socket head screws, screw threads, small solid rivets, and large rivets. The balance of the volume is devoted to lists of standards and their issuing agencies in the United States, including the military serivices; a résumé of fastener materials and manufacturing processes; tables of weights of products; tables giving stock production sizes; terminology and recommended abbreviations; and a detailed index of the entire volume.

MAINTENANCE

Illustrated Design Manual for the Repair of Aluminum Alloy Structures, with Particular Emphasis on Aircraft Construction. Edited by Howard M. Jensen. Bethpage, L.I., N.Y., Johnson Research Corporation, 1952. 200 pp., diagrs., figs. $3.50.

Section I contains general information on types of damage and reviews accepted methods for their detection and analysis. The emphasis is on the practical approach. Section II describes and evaluates materials and processing methods. Data are included on such topics as handling of extrusions, rivets, screws, bolts, welding, air and pressure tightness, finishing methods, and mass-balancing of control surfaces. Considerable data on steel tubing and its repair are given. Section III treats of actual repair problems and cites typical examples. Drawings and tables are used in the discussion. Problems of dissimilar metals in contact, such as aluminum and other alloys, are covered. In Section IV, specifications (sizes, weights, materials, AN numbers) of standard fasteners are presented. The final part of the book, Section V, consists of an appendix containing mathematical tables, solutions of formulas, and equations.

MATERIALS

Treatise on Powder Metallurgy. Vol. 3, Classified and Annotated Bibliography. Claus G. Goetzel. New York, Interscience Publishers, Inc., 1952. 899 pp. $22.

Almost 12,000 references are assembled in this final volume of *Treatise on Powder Metallurgy*. The volume is divided into two main parts. The first contains a classified, annotated bibliography of published books, reports, and periodical articles; the second part contains a classified, annotated survey of the patent literature, United States and foreign. The organization of both of these parts has been carried out to conform closely to the arrangement of the text in Volumes 1 and 2. There are also an 8-page Patent Cross Index referring to patent citations in the first two volumes, a 5-page index of subjects, and a 77-page author index. Both parts of this volume contain references up to January 1, 1950. Exceptions are a few items published in 1950 (new books and continuations of parts of periodical articles published previously) and the proceedings of a symposium sponsored by Sylvania Electric Products Company in January, 1951. In addition to the subjects of pigments, metallic coatings, and catalysts, which might be considered to be fringe applications, there are included in the bibliography metal powder applications in metallurgical processes and their production as a step in the refining or processing of ores. Also included are specific machinery used in powder metallurgy and devices used in testing and classifying metal pow-

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ders. In the compilation of this bibliography, the author made use of previously published bibliographies on powder metallurgy and combined with these his own collection of references, which was started in 1936 in the form of a cross index on cards arranged according to subjects, as well as authors and inventors. The present volume is undoubtedly the most comprehensive work of its kind ever published on the subject. It should prove of great help and utility to the research and technical worker, the industrialist and plant engineer, the inventor and patent attorney, the librarian, and the general student of the art.

Thermodynamics of Alloys. Carl Wagner. Translated by Svante Mellgren and J. H. Westbrook. Cambridge, Mass., Addison-Wesley Press, Inc., 1952. 161 pp., figs. $6.50.

This is an enlarged and revised translation of the author's treatise in Vol. 1, Part 2, of the *Handbuch der Metallphysik* (Berlin, 1940). Emphasis is laid on the principles, but many data for specific systems are presented to illustrate the application of general relations. The most important for alloys thus far investigated have been compiled in tables. The reader may readily obtain complete information on a particular system with the aid of the alloy index and the bibliography, which comprises 419 entries.

Contents: Introduction to General and Thermodynamic Relations. Equations of State for Solutions with Substantially Disordered Atomic Distribution. Equations of State for Solutions with Substantially Ordered Atomic Distribution. Relations Between Thermodynamic Functions and the Phase Diagram. Heats of Formation. Free Energies, Activities, and Activity Coefficients. Equilibria Between Liquid Alloys and Melts of Oxides, Silicates, Sulfides, Halides. Commonly Used Symbols. Bibliography. Subject Index Alloy Index.

Elements of Ceramics. F. H. Norton. Cambridge, Mass., Addison-Wesley Press, Inc., 1952. 246 pp., illus., diagrs., figs. $6.50.

This book is designed to cover the principles underlying the various processes used in the ceramic field, with illustrations to make their application clear. The emphasis is placed on unit processes rather than products, with particular attention to crystal physics. The volume is intended as an introductory college text, as a reference for research workers in ceramics, and as an aid for advanced ceramic craftsmen. The scope of the book includes whitewares, enamels, refractories, glass, cements, fired building materials, and abrasives. Pertinent references to publications in English are given at the end of each of the 24 chapters. Tables, graphs, and process diagrams are employed extensively. The appendix contains detailed design information on small kilns for laboratory use and tables of bodies, glazes, stains, colors, material weights, atomic weights and ionic radii, and temperature and thermocouple data. The combined name and subject index is followed by a table of symbols and units. F. H. Norton is Professor of Ceramics, M.I.T.

Glass; A Handbook for Students and Technicians. Edited by J. Home Dickson. London, Hutchinson & Company (Publishers) Ltd.; New York, Chemical Publishing Company, Inc., 1951. 300 pp., illus., diagrs., figs. $6.00.

This book on glass, which gives an overall picture of its structure, composition, manufacture, and applications, was written by leading technologists in the industry, each a specialist in the subject of his contribution. The book is divided into three main parts. The first, General Principles, covers the nature, chemistry, and physical properties of glass and optical glass. The second part, Manufacture, treats the principles of glass manufacture, molded and blown glass, flat glass, and optical glass. Part 3, Applications, is concerned with chemical glassware, safety glass, glass in building, fibrous glass, glass-to-metal seals, and colored glasses. Chapter references are made throughout as guides for further reading. There are a combined index and glossary of technical terms and an appendix on

the light transmission of colored and special glasses. Photographs and diagrams are used liberally, and 24 tables have been reproduced in the text.

SCIENCES, GENERAL

MATHEMATICS

Statistical Theory with Engineering Applications. A. Hald. New York, John Wiley & Sons, Inc., 1952. 783 pp., figs. $9.00.

The aim of this work, which is an expanded version of the author's Danish textbook published in 1948, is to provide a fairly elementary mathematical treatment of statistical methods of importance to the engineer in his daily work. The choice of the statistical methods considered has been much influenced by the works of R. A. Fisher. The main stress has been laid on the normal distribution and tests of significance connected with this distribution. The problems of statistical quality control have been dealt with according to the point of view of W. A. Shewhart. Certain subjects (the theory of growth curves, time series, stochastic processes) have only been outlined to draw attention to the problems because of their extent and the state of the statistical methods involved.

Only a knowledge of standard differential and integral calculus is assumed necessary for proper understanding of the work. Every important theorem is illustrated with examples from actual work; most of these are drawn from the author's industrial and engineering practice. Literature references are discussed toward the close of most chapters, and the author, Professor of Statistics, University of Copenhagen, has provided an index of author references, an index of symbols and formulas, and an index of subjects.

Statistical Tables and Formulas. A. Hald. New York, John Wiley & Sons, Inc., 1952. 97 pp. $2.50.

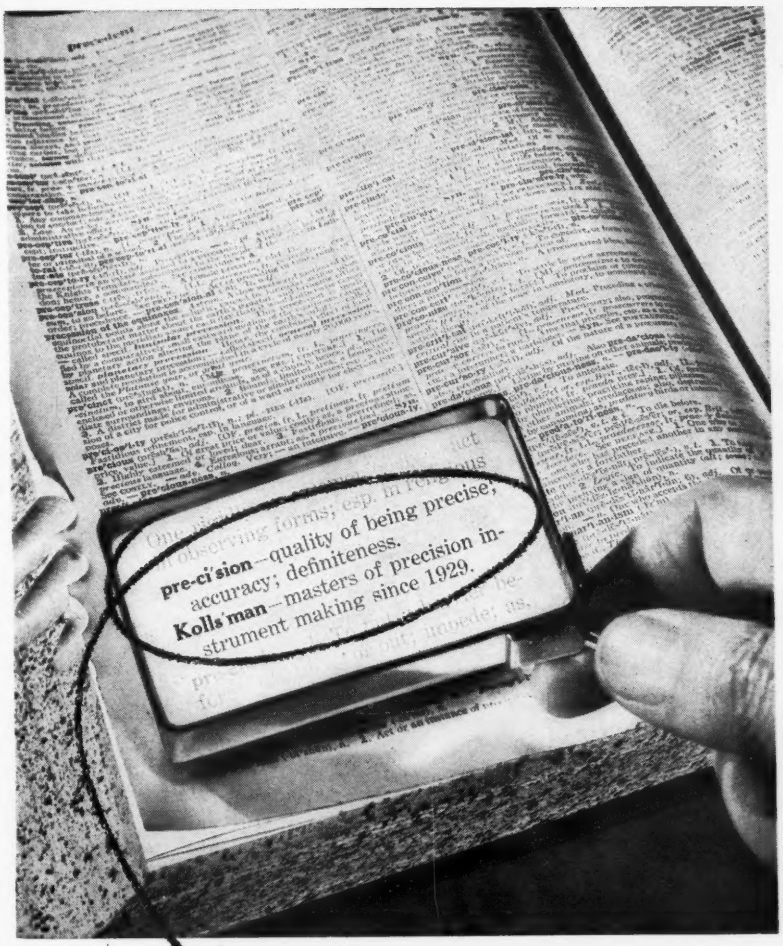
This is a companion volume to *Statistical Theory with Engineering Applications*. A survey of the most important formulas given in the textbook is presented, and tables for use in connection with these formulas are given. Together with the formulas, references are given to the textbook where proofs and examples may be found. The principles used for tabulating the distribution are those of R. A. Fisher. The tables contain 21 fractiles for the t-, χ^2-, and W-distributions, and 17 for the v^2-distribution, representing an extension of previously published tables. Linear interpolation both with respect to probability level and number of degrees of freedom will be sufficient for most applications in practice. Also, distribution and power curves may easily be drawn from the tables, in particular when using probability or logarithmic probability paper. References are listed for each table.

Theory of Matrices. Sam Perlis. Cambridge, Mass., Addison-Wesley Press, Inc., 1952. 237 pp. $5.50.

The main theme is the establishment of the well-known canonical forms. Following chapters on introductory concepts and vector spaces, the topics of rank, nonsingularity, and inverses are introduced in connection with the development of canonical matrices under the relation of equivalence and without the intervention of determinants. Congruence and Hermitian congruence are the next major topics. Polynomials over a field, matrices with polynomial elements, and similarity are then treated. The final chapters deal with characteristic roots and linear transformations. Numerous supplementary topics are treated in appendixes located at the ends of various chapters.

The author, Associate Professor of Mathematics, Purdue University, has planned the book for mathematics majors taking a first course in the theory of matrices. In addition to proofs, discussions, and illustrative examples, there are numerous exercises, queries inserted in the text, and theorems to be proved by the student. A brief reading list is appended to the final chapter.

Advanced Calculus. Wilfred Kaplan. Cambridge, Mass., Addison-Wesley Press, Inc., 1952. 679 pp., figs. $8.50.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The background assumed for this text and reference book is that furnished by freshman and sophomore courses in algebra, analytic geometry, and calculus. The introductory chapter provides a review of these subjects and serves as a reference list of basic definitions and formulas. In the treatment of the subject matter, applications and physical motivation are emphasized. Vectors are introduced at the outset, and numerical methods of integration and of solving differential equations are given prominence. A large number of problems, with answers, is distributed throughout the text. The author is Associate Professor of Mathematics, University of Michigan.

Contents: Introduction. Review of Algebra, Analytic Geometry and Calculus. Chapter 1, Vectors. Chapter 2, Differential Calculus of Functions of Several Variables. Chapter 3, Vector Differential Calculus. Chapter 4, Integral Calculus of Functions of Several Variables. Chapter 5, Vector Integral Calculus; Part I, Two-Dimensional Theory; Part II, Three-Dimensional Theory and Applications. Chapter 6, Infinite Series. Chapter 7, Fourier Series and Orthogonal Functions. Chapter 8, Ordinary Differential Equations. Chapter 9, Functions of a Complex Variable. Chapter 10, Partial Differential Equations. Index.

Geometry and the Imagination. D. Hilbert and S. Cohn-Vossen. Translated by P. Nemenyi. New York, Chelsea Publishing Company, 1952. 357 pp., illus., figs. $5.00.

A presentation of geometry in its visual, intuitive aspects. Throughout, the authors offer, instead of formulas, figures that may easily be supplemented by models that the reader can construct. By means of this visual presentation, one who does not wish to follow the details of the analytic arguments may still gain an insight into the manner and validity of the proofs. The volume is a translation of the authors' *Anschauliche Geometrie*, Berlin, 1932.

MECHANICS

Analytical Mechanics for Engineers. Fred B. Seely and Newton E. Ensign. 4th Ed. New York, John Wiley & Sons, Inc., 1952. 443 pp., figs. $5.50.

Principal changes in this edition are the addition of new problems and figures; the use of a general coplanar force system, rather than the simplest type of force system, to introduce and explain the graphic and algebraic methods of determining the resultant of a force system; greater emphasis on distributed forces in determining resultants of force systems; and the elimination in Part 4 on Special Topics of the chapters on Governors and the Gyroscope and the transfer of some of the discussion of the gyroscope to the chapter on Impulse and Momentum.

PHYSICS

Initiation and Growth of Explosion in Liquids and Solids. F. P. Bowden and A. D. Yoffee. New York, Cambridge University Press, 1952. 104 pp., illus., diagrs., figs. $4.50.

This monograph deals mainly with the work of the authors and their collaborators in their study of the decomposition by impact and by friction of explosive substances. The approach is a direct experimental one, and the work is still in progress so that the picture presented is necessarily incomplete and elementary. The experimental work was carried out during the war years in the Tribophysics Division of the Australian C.S.I.R. and, since 1946, in Cambridge, where the authors are with the Research Laboratory on the Physics and Chemistry of Surfaces of the Department of Physical Chemistry. After a brief discussion of the formation of the explosion nucleus and the thermal theory of explosion, the initiation of explosion in liquids and solids by friction is considered. The mechanism of initiation of explosion by impact is then discussed. Chapter 3 begins with liquid explosives, and Chapter 4 describes experiments on the initiation of explosion in solids by impact. Chapter 5 gives a brief account of the developments of some of the high-speed photographic methods and their application to the study of the way in which an explosion grows from the point of initiation and develops into a large-scale detonation. Throughout the monograph, experimental apparatus are described and illustrated, and test results are shown in photographs, tables, and graphs. References to the work of others are made in the text, and a three-page list of references is included.

Aeronautical Reviews

(*Concluded from page 102*)

Thermodynamics (18)

The Theory of Flame Propagation and Detonation. III. C. F. Curtiss, J. P. Hirschfelder, and D. E. Campbell. *Wisconsin University, Naval Research Laboratory, Department of Chemistry, Report No. CM-690*, February 15, 1952. 98 pp., illus. 5 references.

An Active Particle Diffusion Theory of Flame Quenching for Laminar Flames. Dorothy M. Simon and Frank E. Belles. *U.S., N.A.C.A., Research Memorandum No. E51L18*, March 4, 1952. 24 pp., illus. 13 references.

Flame Speeds of 2,2,4-Trimethylpentane-Oxygen-Nitrogen Mixtures. Gordon L. Dugger and Dorothy D. Graab. *U.S., N.A.C.A., Technical Note No. 2680*, April, 1952. 25 pp., illus. 15 references.

Water-Borne Aircraft (21)

The Flyingboat and Its Place in Aviation. Frederick Bowhill. (10th Brancker Memorial Lecture, London, February 11, 1952.) *Institute of Transport, Journal*, Vol. 24, No. 9, March, 1952, pp. 321–330.

An evaluation of the advantages and limitations of the flying boat for transport, the effectiveness of present operations, and the problems of establishing marine and land bases; economic and administrative aspects.

Martin M-270 Twin-Engined Flying Boat. *American Aviation*, Vol. 16, No. 1, June 9, 1952, pp. 26, 27, illus.

Piaggio P-136 Twin-Engined Seaplane Trainer, Italy. James Hay Stevens. *Aircraft Engineering*, Vol. 24, No. 278, April, 1952, pp. 107–111, illus.

Seaplane Sports Quick-Change Hull. *Aviation Week*, Vol. 56, No. 16, April 21, 1952, pp. 46, 47, illus.

Flight- and water-tests of hulls with high length-to-beam ratio on the Petulant Porpoise that is a modification, by the Edo Corp., of a standard Grumman J4F-2 Widgeon. Hull bottoms can be mounted and dismounted easily for testing various hull configurations.

Wind Tunnels & Research Facilities

Triple Velocity Correlations in Isotropic Turbulence. R. W. Stewart. *Cambridge Philosophical Society, Proceedings*, Vol. 47, Part 1, January, 1951, pp. 146–157, illus. 11 references.

Measurement of the triple velocity correlation, using an electronic circuit based on Townsend's triple correlation, of the turbulence produced by the insertion of a square-mesh grid at the beginning of the wind-tunnel working section over a range of Reynolds Numbers covering most of the initial period of the decay of turbulence.

Wind-Tunnel Corrections at High Subsonic Speeds, Particularly for an Enclosed Circular Tunnel. B. Göthert. (*D.V.L., Forschungsbericht, No. 1216*, May, 1940.) *U.S., N.A.C.A., Technical Memorandum No. 1300*, February, 1952. 43 pp., illus. 10 references.

Diffuser Efficiency of Free-Jet Supersonic Wind Tunnels at Variable Test Chamber Pressure. Rudolf Hermann. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 375–384, illus. 2 references.

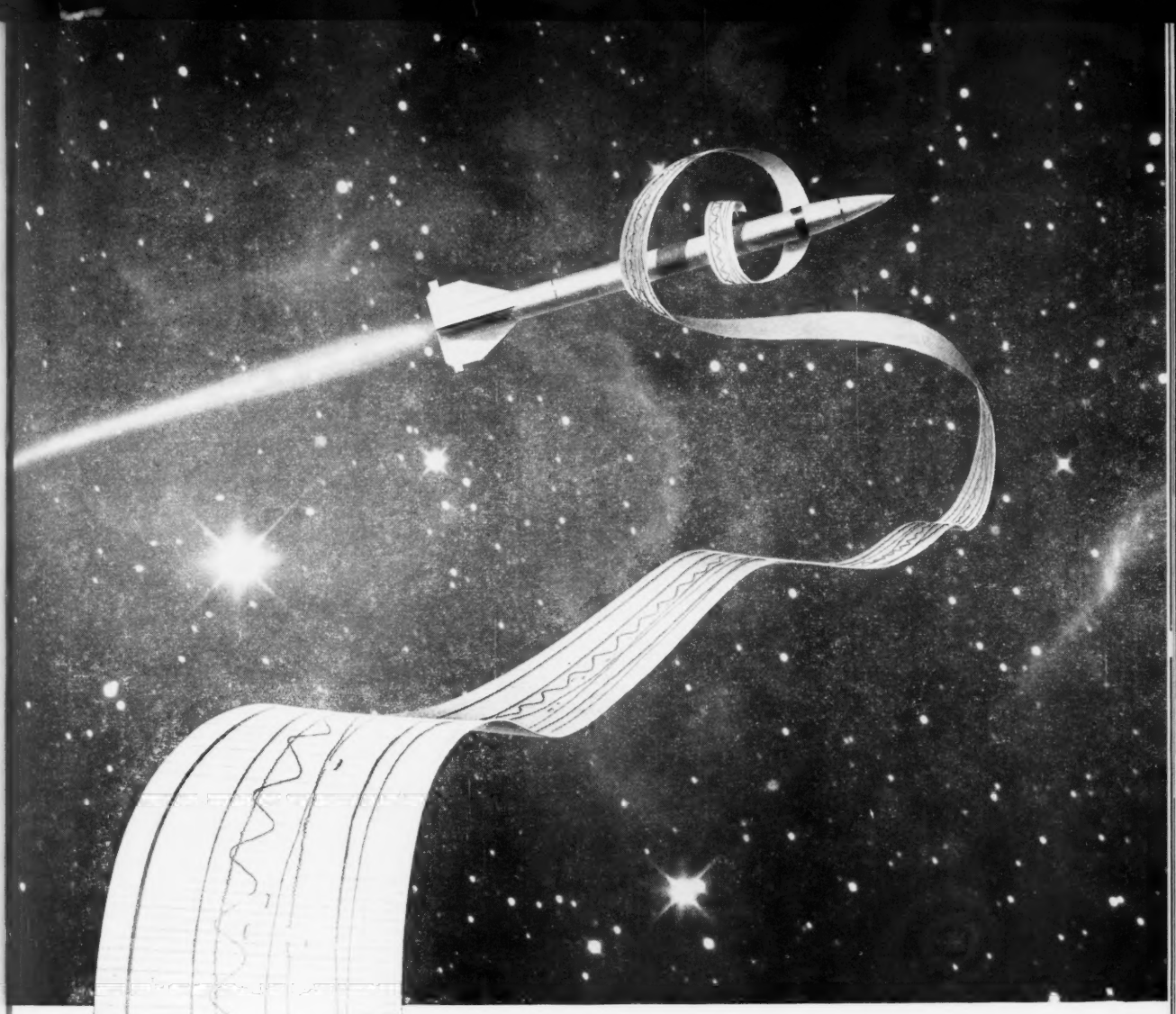
Development of an exact solution for the one-dimensional nonviscous, steady flow in the diffuser of a free-jet supersonic wind tunnel when the test chamber pressure is different from the nozzle exit pressure; explanation of the exact mechanism of test-chamber pressure control by means of the adjustable diffuser.

Readers' Forum: Effect of Wind-Tunnel Nozzle on Steady-Flow Nonuniformities. H. S. Ribner and M. Tucker. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 426, 427, illus. 3 references.

A High-Speed Schlieren Technique for Investigation of Aerodynamic Transients. Walter S. Bradfield and Walter Y. Fish. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 418–420, 432, illus. 3 references.

Development of a high-speed schlieren technique for studying wind-tunnel starting transients and their effect on the initiation of flow in a "choking" supersonic diffuser.

Free-Flight Air-Drag Measurement Techniques. Appendix. R. E. Roberson. *Journal of the Aeronautical Sciences*, Vol. 19, No. 6, June, 1952, pp. 385–390, illus. 1 reference.



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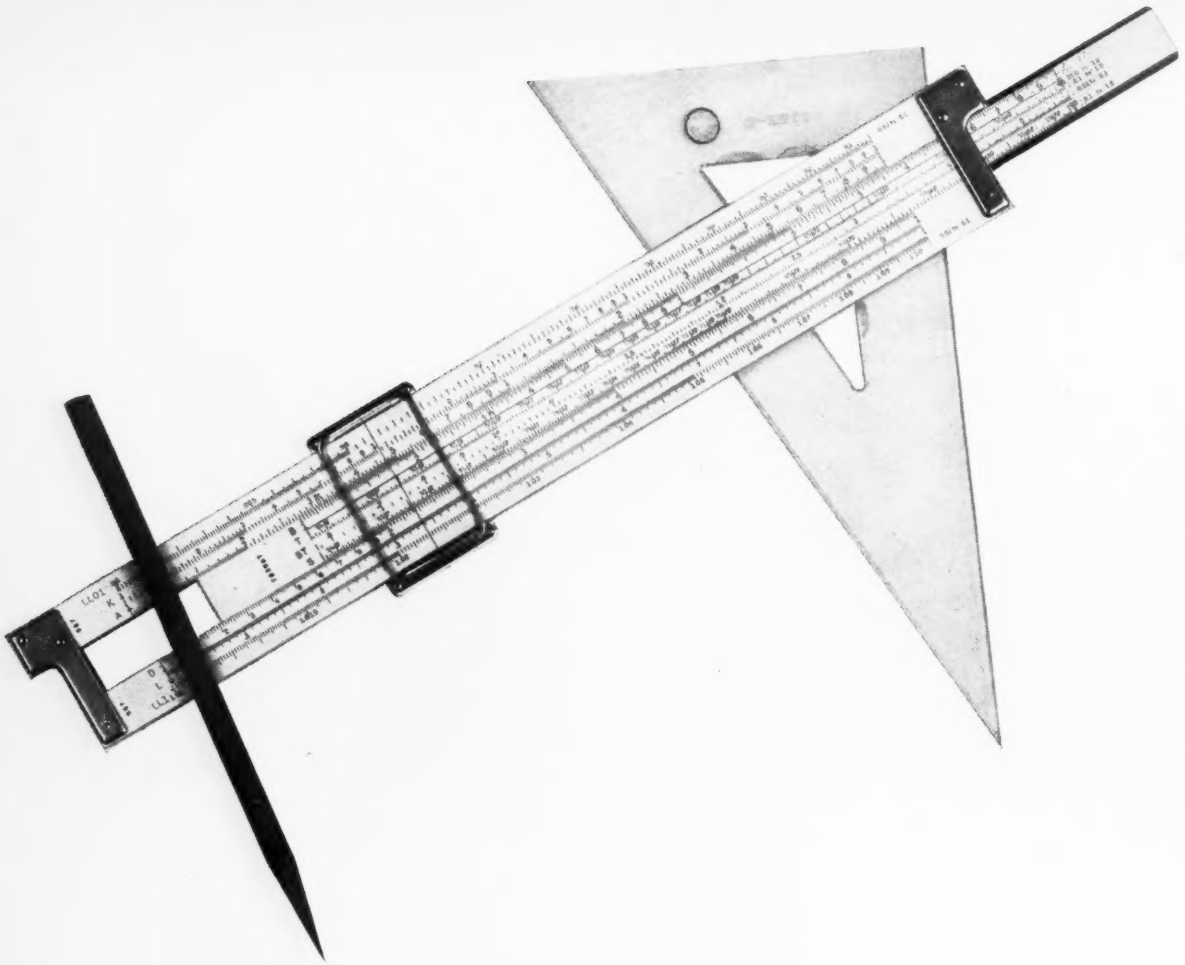

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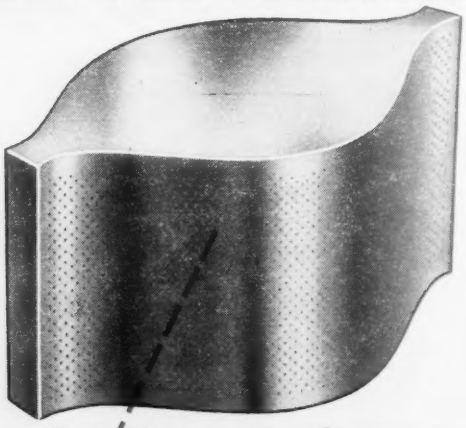

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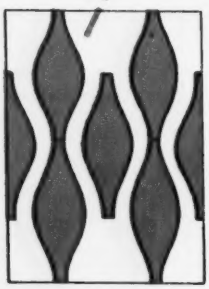

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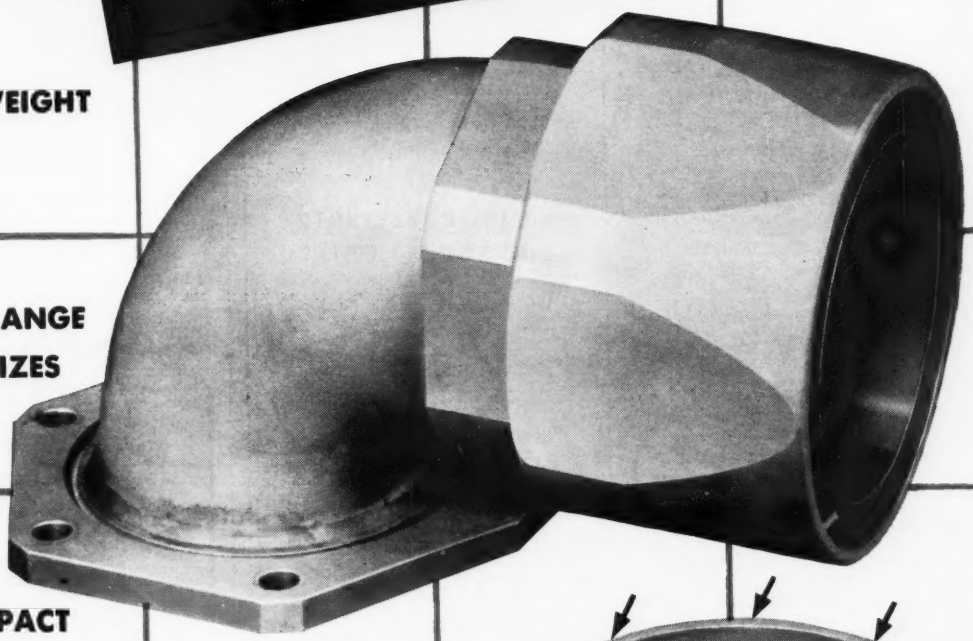

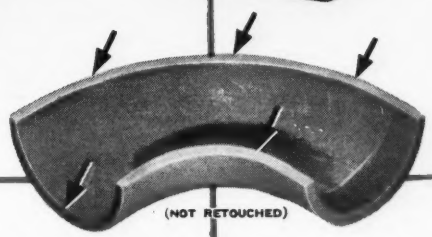

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400. Civil Engineer—B.S. in C.E., 1942. Age 31. Private pilot's license. Experience: Aircraft stress analysis 2½ years; engineering instruction 2 years; field engineering and construction 2½ years to date. Desires work in foreign construction. Must be able to travel with wife. Available in August.

395. Aeronautical Research and Development Engineer—B.Ae., M.S. in Ae.E. Excellent theoretical background. Almost 7 years' experience in dynamics, aeroelastics, stability and control of fixed- and rotary-wing aircraft, missiles. Presently employed in helicopter aeroelastics. Desires responsible position in research and development. Specify nature of position in first letter.

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